HUMAN BIOLOGY
a record of research

DECEMBER, 1957

VOL. 29 No. 4

CHANGES IN BODY VOLUME ACCOMPANYING WEIGHT REDUCTION IN COLLEGE WOMEN[1]

BY MARIE L. CARNS AND RUTH B. GLASSOW
University of Wisconsin

THE problem of obesity has long challenged professional groups and has been a cause of concern to laymen. Unquestionably, overall body weight may be reduced by decreasing the caloric intake. At the same time, many people hope for reduction of excess weight in separate areas of the body, such as the thighs, abdomen and arms. Specific exercises are frequently recommended for this purpose. The effectiveness of such exercises lacks the support of controlled studies. It is the purpose of this study to investigate the overall loss of body volume and the comparative loss of volume in body segments when the caloric intake is reduced.

[1] The data were collected by a graduate student, JoAnn Mann, under the supervision of M. L. Carns, M. D. and E. S. Gordon, M. D., of the faculty of the University of Wisconsin; the study was financed in part by a grant from the Wisconsin Alumni Research Foundation.

PROCEDURE

Ten undergraduate university women were selected for observation from a group of volunteers on the basis of their degree of excess weight, their interest in the project, and their seeming willingness to cooperate. Attempts were made to select women who were not excessively obese but who could afford to lose approximately 20 pounds in a 6 week period. All had received "A" health grades in the University Department of Student Health. Single determinations of basal metabolism and serum cholesterol were made in each subject; there was no evidence from these tests of any significant thyroid dysfunction.

During a 6 week period the subjects were asked to subsist on the diet planned by Ruth Dickie, chief dietician at the University Hospital where all meals were prepared and eaten. The total dietary intake per day for each woman ranged from 900 to 950 calories. This was apparently adequate for the subjects; all of them reported that they could easily carry on their usual campus activities without a feeling of fatigue or hunger.

Changes in body mass were measured by two methods. One was weight in pounds. Weight was taken prior to the controlled diet period and also at the end of each week of the 6 weeks of the diet program. At each weighing the subjects wore the standard swimming suits used by the Department of Physical Education for Women.

The second measure was body volume determined by the amount of water displaced by the body. A metal cylinder approximately 6 feet in height and two feet in diameter, open at the top, was filled with water to an indicated level. In the tank was a ladder which the subject descended to a specified distance. A stopcock in the tank was opened and water, raised by the immersed body segment, was drawn off to bring the water in the tank to its original level. Thus the water drawn from the tank was equal in volume to the volume of the immersed body segment. The amount was determined by weighing. The temperature of the water was kept at approximately 80° F. The measurements on each subject were always taken at the same time of day.

In order to obtain the volume of separate segments of the body, 6 anatomical points were chosen to locate division lines. These were: A, the apex of the fibular head; B, the gluteal fold; C, the greater trochanter of the femur; D, the inferior border of the twelfth rib; E, the ninth thoracic vertebra; F, the seventh cervical vertebra. At each

of these points, an aluminum marker was attached with adhesive tape before the subject entered the tank. The letters A through F are used to indicate division lines and also to designate body segments. In referring to segments, a letter represents the division immediately below

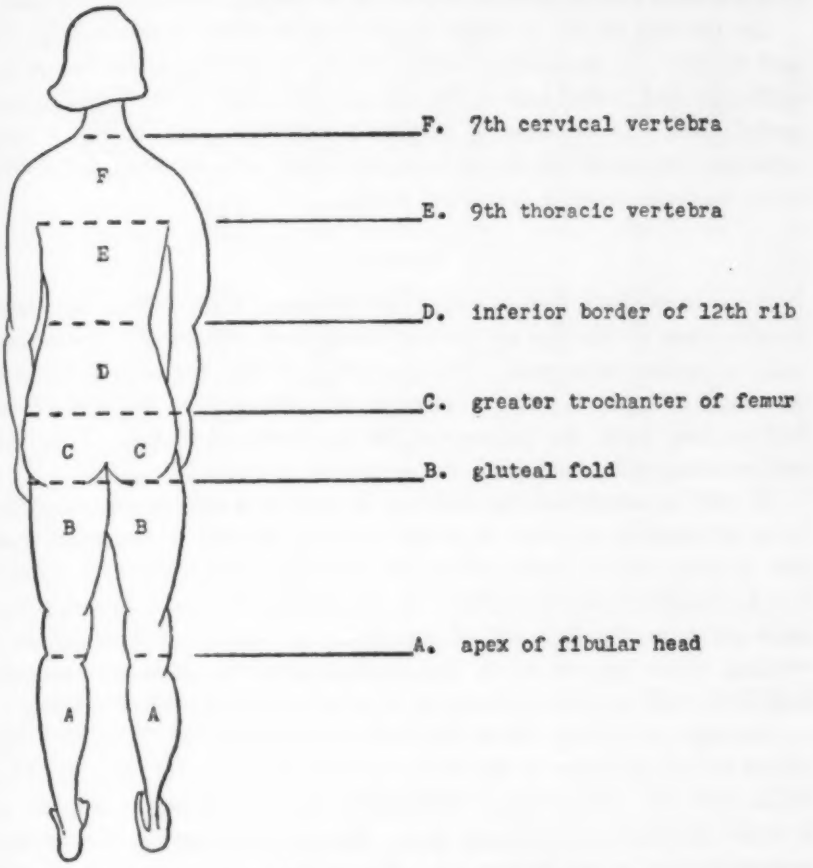


FIG. 1. BODY SEGMENTS AND DIVISION LINES.

the division line. The volume was determined for each body segment. The hands and arms were kept out of the water until the F readings were taken. F segment, therefore, includes the upper trunk and the arms and hands. (See figure 1.) The sum of the 6 volumes measured on the same day represents the volume of the entire body up to the F marker.

All division points except D and E were located by palpation or inspection or both. Points D and E were located in the first of the weekly measures by the above procedures. At this time, the distance from the adjoining marker was measured and in the succeeding weeks D and E were located by referring to the previously determined distances.

At the end of the 6 weeks of observation there were available for each subject (1) measures of body weight, in pounds, taken before the controlled diet period and at the end of each week of the experimental period; and (2) amounts of displaced water for each of the 6 body segments, measured at the end of each week of controlled diet. The latter measures were in pounds of water.

RESULTS

1. *Loss in Body Weight and Total Volume.* Body weight and water weight taken at the end of the first week were selected for comparison with succeeding measures. The percentage of loss for each variable is tabulated in table 1. If no measure was obtained at the end of the first or final week, the percentage has not been calculated. Thus, the volume changes for subjects I and V are not in table 1.

It will be noted that the decrease in volume scores is approximately twice as much as the loss in weight scores. Weight losses range from 5% to 9%; volume losses from 9% to 19%. Note that the volume loss for subject X is not included in this range. It seems probable that some error in the first set of measures for subject X resulted in a reading which appears to be inconsistent with the other measures on subject X and also inconsistent with measures of the other subjects.

Average percentage losses are shown graphically in figure 2. The values are the averages of the losses of subjects in II, III, IV, VI, VII, VIII, and IX. The average percentage loss for volume at the end of 6 weeks for the 7 subjects was 14.7. For the same period, the average percentage loss in weight was 7.6. This is the only presentation of data which does not include the 10 subjects.

2. *Group Segmental Losses.* Table 2 shows the average loss for each segment, the range of these losses, and the rank of each segment according to average loss. The segments may be grouped according to the amount of loss, *i.e.*, low (A and E); medium (B and C); and high (D and F). The averages provide a basis for comparison of individual losses. Note that the range for segment D (17.5-20.9) is

TABLE 1

Weekly decrease in volume and weight

SUBJECT		WEEK-KG.	1ST	2ND	3RD	4TH	5TH	6TH	TOTAL LOSS
			PERCENTAGES						
I	Volume	52.6	—	—	—	—	—	—	—
	Weight	59.9	100	98	97	95	94	92	8
II	Volume	63.5	100	97	94	91	88	86	14
	Weight	74.4	100	97	95	93	92	92	8
III	Volume	48.1	100	97	92	90	85	84	16
	Weight	59.9	100	97	95	94	93	93	7
IV	Volume	56.7	100	98	94	92	84	83	17
	Weight	64.0	100	97	96	94	92	91	9
V	Volume	—	—	—	—	—	—	—	—
	Weight	69.9	100	98	97	94	94	93	7
VI	Volume	56.2	100	97	—	92	89	86	14
	Weight	62.6	100	99	97.8	96	94	93	7
VII	Volume	58.1	100	94	91.8	86	85	81	19
	Weight	62.6	100	97	95.6	93	91	91	9
VIII	Volume	58.5	100	98	98.7	95	92	86	14
	Weight	66.7	100	99	96	94	93	92	8
IX	Volume	56.2	100	96	94	92.8	94	91	9
	Weight	57.6	100	98	97	97	96	95	5
X	Volume	74.9	100	82	75	73	72	—	28
	Weight	67.1	100	97	95.9	95	92	91	9

Volume (up to seventh cervical vertebra) in kilograms of displaced water. Weight in kilograms, total body.

Note: both volume and weight were measured in pounds and, to conform to the policy of this periodical, converted to kilograms.

TABLE 2

Average percentage volume losses per segment

SEGMENT	AVERAGE LOSS	RANGE OF LOSS	RANK
A	12.8	9.6–15.2	6
B	16.9	12.1–24.2	3
C	16.7	14.8–21.8	4
D	19.0	17.5–20.9	2
E	13.7	9.2–18.2	5
F	20.3	15.2–24.7	1

close to the average (19.0) and that the individual differences in segments B and F are greatest.

3. *Individual Segmental Losses.* The weight of the water displaced by one segment is a percentage of the weight of the total amount of

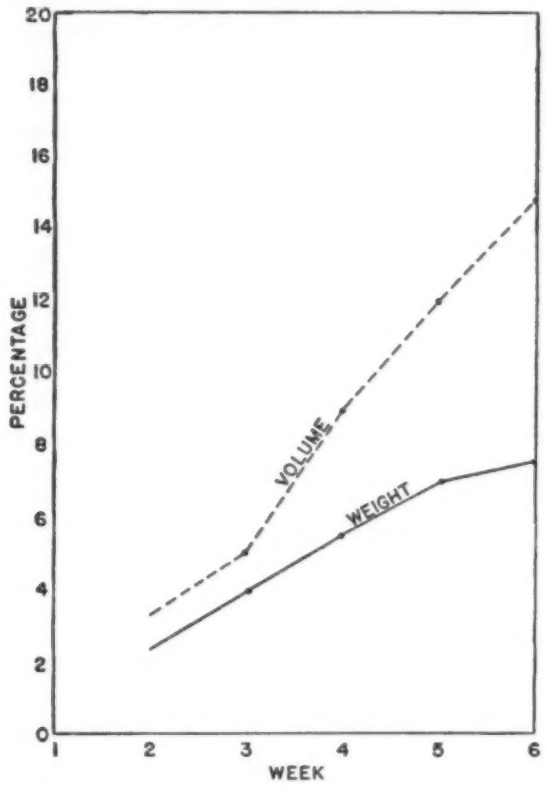


FIG. 2. WEEKLY PERCENTAGE LOSSES—AVERAGE FOR SEVEN SUBJECTS.

displaced water and can be considered a volume percentage of the total body volume. The differences in segmental percentages for the initial and final measures indicate changes in body proportions. In table 3 are listed for each subject the greatest segmental differences (in percentages) and the area in which these differences were found. At the time of the initial measurement, two investigators estimated the area of greatest fat deposit. Except for subject IV, the area of greatest

proportional loss is the one which the experimenters identified as that of the greatest initial fat deposit. It will be noted that the area of greatest loss for subject IV is E which is immediately above D, the area which was subjectively ranked as the area of greatest fat deposit.

TABLE 3

Segmental changes in relation to total volume

SUBJECT	GREATEST DIFFERENCE IN PER CENT	AREA	AREA OF GREATEST FAT DEPOSIT
I	3.1	F	F
II	3.1	B	B
III	1.6	C	C
IV	3.0	E	D
V	3.3	E	E
VI	2.3	C	C
VII	1.9	D	D
VIII	2.7	E	E
IX	1.6	D	D
X	3.8	E	E

TABLE 4

Average segmental percentage of total volume

SEGMENT	INITIAL	FINAL
A	12.8	13.2
B	18.2	18.8
C	16.3	16.0
D	18.7	19.4
E	13.5	11.7
F	20.0	20.4

4. *Changes in Body Proportions.* Another aspect of the changes in body proportions is shown in table 4 which presents the average volume percentage of the total volume.

The greatest average change in body proportions is shown in segment E. (Table 3 shows that this was the segment in which the greatest number of individuals had the greatest loss.) Negligible change in

the same direction was present in segment C. It is interesting to note that segment F, which was the area of greatest average loss in volume, retains the same proportion of the total body volume at the time of the first and final measures.

The range of these segmental percentages is also of interest. These are shown in table 5.

TABLE 5

Range of individual differences in segmental volume

SEGMENT	INITIAL MEASURE	FINAL MEASURE
A	4.9	3.3
B	6.4	6.5
C	7.6	6.8
D	3.5	8.2
E	8.8	11.4
F	8.1	4.5

The range of proportions of segments B and C have changed little; the proportions of segments A and F are more alike in the final measures than they were in the first measures and segments D and E are less alike in body proportions than they were before the dieting period.

COMMENT

No statistical evidence of the significance of findings has been attempted. In the writers' opinion, the significance of the observations lies in the fact that all subjects conform to the general findings: the percentage loss of volume is twice that of the percentage loss of weight (the one exception is attributed to measurement error); the area of greatest loss is that of greatest fat deposits (the one exception is attributed to error in subjective evaluation). The evidence suggests that these are physiological phenomena.

The implications which this study has for future investigations are more significant than the specific information on the amounts of local and total volume reductions. The implications seem to the authors to be twofold.

First, those professions which attempt to stimulate interest in reduction of fat might be more successful in obtaining cooperation of women

if a convenient measure of volume could be devised. Since the proportionate loss in volume is greater than that in weight, the more evident result would be a motivating factor in continued effort. Also, women are more interested in size than in weight of body mass.

Second, those professions which advise exercises for reduction of size of specific body areas, have as yet no conclusive evidence that these exercises are effective. If, as this study suggests, reduction of caloric intake reduces volume to the greatest degree where fat deposits are largest, there is need for studies which will determine the amount of volume reduction which can be attributed to localized exercises.

SUMMARY

This exploratory study of loss in body volume of 10 university women during 6 weeks of a reducing diet indicates the following tentative conclusions.

1. The percentage loss in volume is approximately twice that of percentage loss in weight.
2. While there is an overall loss in volume,
   a. the area of greatest loss differs among the individuals,
   b. and each individual tends to lose proportionately more in the area where fat deposits are largest.
3. After dieting, body proportions tend to show
   a. a decrease in individual differences in lower extremities and in shoulders and upper extremities.
   b. an increase in individual differences in the trunk.

DOMINANCE OF EYE AND HAND

BY DAVID J. MERRELL

Department of Zoology, University of Minnesota

A fascinating array of superstitions and facts has grown up around man's tendency to have a preferred hand. In most cases the superstitions are even more interesting than the facts, although it is not always possible to separate one from the other. Since the great majority of people in all groups studied are right-handed, left-handed people have long been regarded as in some way peculiar or eccentric, or clumsy, or as evil or of bad omen (*e.g.*, compare the derivations of gawky and dextrous, sinister and righteous). These beliefs are not only reflected in language, but play a part in many religious, cultural, and social practices as well. Furthermore, left-handedness has been reported to be unusually common among mental defectives, epileptics, psychotics, "degenerates," draft rejectees, and children with emotional disturbances, behavior problems, and speaking, writing, reading, or spelling difficulties (see Wile, '34 for further discussion).

Dominant handedness has been ascribed to a variety of causes, both hereditary and environmental. One of the most interesting theories, because it represents Darwinian selection in its simplest form, is the primitive warfare theory. The preference for the right hand is presumed to have arisen because the left hand was needed to hold a shield over the heart while the right wielded a spear or sword. Those who held the shield in the right hand were more likely to suffer fatal wounds in the heart, and hence the left-handed in the course of a few thousand years of primitive warfare were reduced in frequency by natural selection (Pye-Smith, 1871; Thomas Carlyle in Froude 1884; Gould, '08; Woodruff, '09). Even more widespread and more generally accepted has been the theory that the dominant hand is determined by the dominant eye (Callan, 1881; Le Conte, 1881; Gould, '08; Parson, '24; McAndrews,

'35; Fink, '38; Wile, '42; Berner and Berner, '53), although opinion and some evidence to the contrary has also been presented (Stevens, '09; Kuroda, '27; Woo and Pearson, '27; Miles, '30; Krimsky, '48; Walls, '51). In connection with this theory, the difficulties in speech, writing, etc., have been attributed to mixed dominance of eye and hand, and treatments have been based on this concept (Wile, '42; Berner and Berner, '53).[1] Some of the difficulties in assessing and comparing the results of previous studies arise because of a lack of information about the criteria used to establish preference or because different criteria have been used in different studies.

THE RELATIONSHIP BETWEEN VISUAL ACUITY AND OCULAR DOMINANCE

Sir Francis Galton was one of the first to make a scientific study of lateral dominance of hand and eye in man. He collected a considerable amount of data at the Health Exhibition of 1884, which were then stored at the Galton Laboratory until analyzed much later by Woo and Pearson ('27). His criterion of handedness was the strength of grip by the right and left hands as measured by a dynamometer. The stronger hand was considered to indicate the hand preferred for acts requiring only one hand. The criterion of ocular dominance was visual acuity, which was measured in terms of the ability to read diamond type. As Woo and Pearson recognized, strength of grip may not necessarily indicate the hand preferred for tasks requiring dexterity or manipulative skill, nor may the dominant or master eye necessarily have the greater acuity. A variety of tests for ocular dominance has been used, but the essential phenomenon is one of binocular vision (Walls, '51). Under certain circumstances, even though both eyes remain open, only one can be used effectively, as, for example, in lining up a vertical pencil with a distant tree. There then occurs a suppression of vision in one eye, described by Krimsky ('48) as a "suspension of critical foveal vision in the non-dominant eye, while the dominant eye assumes the role of fixation." Woo and Pearson proceeded with their analysis upon the assumption that visual acuity and strength of grip were valid criteria of the dominant eye and hand, and reported that they could find no correlation whatever between

[1] The Berners distinguish between the dominant eye and the "controlling eye." However, they fail to tell how the dominant eye was determined, and their "controlling eye" appears to be what others regard as the dominant eye.

ocular and manual dominance. Although they felt that visual acuity was actually a better measure of ocular dominance than the various sighting tests commonly used, it is clear from their data that they obtained quite different results from other workers. They found 22.82% "ocular dextralists," 54.79% "ocular ambilateralists," and 22.39% "ocular sinistralists," whereas McAndrews ('35), summarizing the results of several others using sighting tests, reported 75% right eyed, 23% left eyed, and 2% indifferent or mixed, and Miles ('30) reported for the same types 64%, 34%, and 2% respectively. Mills ('25) had noted that the dominant eye sometimes had the poorer vision, and Gahagan ('33), in a study of 100 emmetropic university students, found that there was no relationship between visual dominance and acuity, a result borne out for a completely unselected group in the present study.

Two tests were used to determine the master eye in the work to be reported. One is similiar to the "finger pointing" test of Callan and Le Conte. As conducted here, a finger or a pencil held vertically is lined up, with both eyes open, with a vertical structure such as a tree trunk or the edge of a window or door. When the eyes are closed alternately, it is found that the pencil and the tree are no longer lined up when the dominant eye is closed. The other test, used in the questionnaire, involved puncturing a hole the size of a pencil in a large sheet of paper, which is then held at half an arm's length by the subject. In the other hand, a pencil held vertically at full arm's length is lined up by the subject with both eyes open, so that it is visible through the hole. When the dominant eye is closed, the pencil cannot be seen. Individuals wearing glasses were not requested to remove them, and hence the tests were made with corrected vision. Tests used by others (see Fink, '38 and Walls, '51 for further discussion) include looking through a cylinder at a distant object, Parson's "manuscope," a convergence test (as the object approaches the face until both eyes can no longer focus on it simultaneously, the non-dominant eye drifts away first), and sighting at a reasonably distant object through a small hole in a card held with both hands. The purpose of this last test is to cancel out the effect of handedness on the determination of the dominant eye, a possible defect in the two methods utilized for this report, but, as we shall see, a precaution which is apparently unnecessary. Generally the dominant eye was determined very quickly, but in a few cases difficulties were encountered because the subject could sight with either eye. Among those tested personally, it was possible, by the use

of different variations of the test, to determine a preferred eye in all but one case. However, it was obvious that there is some variation in the strength of dominance among different individuals. In the pedigrees received there were 4 individuals (0.8%) who listed both eyes as dominant, and they were therefore omitted from the data.

The individuals in the present study were requested, if one of their eyes was "weaker" than the other, to make note of it on the questionnaire, specifying the weaker eye. While "weaker" may be an ophthalmologically unsophisticated term, it was intelligible, and the dominant eye of those specifying a "weaker" eye is shown in table 1. Possibly

TABLE 1

Relationship between the "weaker" eye and the dominant eye

Dominant eye	"Weaker" eye	*n*
R	R	19
R	L	13
L	R	15
L	L	6
		53
$\chi^2 = 0.17$	$p > 0.95$	

tests with uncorrected vision might have modified these results, but it seems unlikely because, among those tested personally with corrected and then uncorrected vision, the dominant eye remained the same. Hence, it must be concluded from the difference in frequency between Woo and Pearson's data and those of other workers (*e.g.*, Miles, '30), from Gahagan's results, and from the data in table 1 that there is no relationship between visual acuity and ocular dominance. Walls ('51) postulated that sighting dominance is not a sensory or perceptual phenomenon at all, but rather a motor ocular dominance related to the patterns of innervation sent to the rotatory muscles of one eye only, a theory which seems reasonable in the light of the above results on visual acuity.

CRITERIA FOR THE DOMINANT HAND

A number of criteria of handedness have been used. Most of these tests determine the hand preferred for some one-handed manipulation

such as throwing, writing, bowling, or sewing, rather than strength. Though there are apparently no data correlating strength with dexterity, the frequencies of Woo and Pearson for strength of grip (64.37% "manual dextralists," 6.73% "manual ambilateralists," 28.90% "manual sinistralists") are similar to the frequencies obtained by manipulative tests, though with a somewhat higher percentage of left-handedness. Rife ('40, '50) used 10 criteria of handedness, and classified those using the left hand for one or more of the operations as left-handed, "on the assumption that ordinary environment favors right-handers." In the present study, 4 criteria of handedness were used—throwing, writing, striking a match, and threading a needle—while kicking served as the criterion for the preferred foot. When the various criteria were grouped, the convention adopted by Rife was followed. Furthermore, for similar reasons ambidexterity on a test was taken as indicative of left-handedness (Hurst, '12). This arbitrary decision had little effect on the analysis, for only 8 out of the 497 people in the pedigrees indicated use of either hand for one or more of the tests.

Needle threading was thought to be a useful addition to the tests of handedness used by others because, although generally not taught, it requires a high degree of manual skill, and is performed so seldom by most men that for them it should be relatively free of environmental influence. The hand guiding the thread was regarded as the preferred hand. It should be noted that very few of the persons tested knew which hand they used to thread a needle or which eye was their dominant eye, or even that they had a dominant eye.

RESULTS

Table 2 gives the frequency of the 6 traits studied. One hundred twenty-three persons were tested by the author personally so that the frequencies in this random unrelated group could be compared with the family groups obtained through correspondence. The excess of males is due to the greater number of male university students in the tested group and serving as propositi for the pedigrees. There are no significant differences between males and females or between the tested group and the family groups for any of these traits.

Table 3 shows the relationship among the various tests of handedness and kicking. The extremely large and highly significant chi-square values for all tests indicate that threading, throwing, writing,

TABLE 2

Per cent with left side dominant for the 6 traits analyzed

TRAIT		*n*	DOMINANT EYE %L	NEEDLE THREADING %L	THROWING %L	STRIKING MATCH %L	WRITING %L	KICKING %L
Tested [a]	♂	72	27.8	19.4	6.9	4.2	4.2	5.6
	♀	51	41.2	19.6	7.8	3.9	3.9	13.7
	T	123	33.3	19.5	7.3	4.1	4.1	8.9
Pedigrees	♂	261	31.8	14.6	9.2	8.0	6.9	7.7
	♀	236	30.9	19.9	7.2	8.5	6.4	6.4
	T	497	31.4	17.1	8.2	8.2	6.6	7.0
Total [b]	♂	313	30.7	14.7	8.6	7.7	6.7	7.3
	♀	264	31.1	19.7	6.4	7.6	5.7	6.8
	T	577	30.8	17.0	7.6	7.6	6.2	7.1

[a] Tested by the author.

[b] Less than the sum of tested and pedigree groups because 43 persons were common to both groups.

TABLE 3

Relationship between various traits

COMBINATION	THREADING-THROWING	THROWING-KICKING	KICKING-STRIKING MATCH	STRIKING MATCH-WRITING	HAND (ALL CRITERIA)-KICKING	HAND (OMITTING THREADING) KICKING	THREADING-HAND (OTHER CRITERIA) & KICKING
RR	403	450	447	453	399	444	399
RL	9	6	15	3	3	3	13
LR	53	11	9	12	63	18	45
LL	32	30	26	29	32	32	40
χ^2	112.42**	275.61**	215.89**	311.55**	127.12**	277.28**	137.97**

** $p < .01$

and striking a match are related to each other and to kicking, and that there is a fundamental preference for using the arm and leg on one side of the body for most tasks. The considerably higher frequency of left-handedness for threading as compared to the other traits and to most other studies (see Wile, '34, for summary) would seem to indi-

TABLE 4

Relationship between dominant eye and hand

COMBINATION	EYE-THREADING	EYE-THROWING	EYE-KICKING	EYE-STRIKING MATCH	EYE-WRITING	EYE-HAND (ALL CRITERIA) & FOOT
RR	292	321	322	320	327	281
RL	48	19	18	20	13	59
LR	119	135	140	137	137	115
LL	38	22	17	20	20	42
χ^2	7.61	9.96*	5.23	7.23	13.71**	6.08

* $p < .05$
** $p < .01$

TABLE 5

Dominant eye in persons completely left-handed or right-handed (by 5 tests)

HAND	EYE	n	n*
R	R	281	287
	L	115	118
L	R	6	9
	L	11	11
χ^2		9.90*	5.91

* Four additional pedigrees received after the analysis had been completed are included here because the additional information is sufficient to shift the χ^2 from the indeterminate range to a non-significant value.

* $p < .05$

cate that this trait is relatively free of environmental pressure to conform. However, the low frequency of left-handed writers undoubtedly reflects environmental pressures to some extent.

The relationship between dominant eye and handedness is shown in tables 4 and 5. Though significant chi-square values occur, there

appears to be essentially no relationship between the dominant eye and the dominant hand.

Tables 6, 7, and 8 show the type of offspring resulting from different types of mating with respect to handedness. One hundred and three

TABLE 6

Handedness (all criteria—threading, throwing, striking match, writing, and kicking) among offspring from different types of matings

TYPE OF MATING	SIBSHIPS	SONS		DAUGHTERS		TOTAL	
		n	% L	*n*	% L	*n*	% L
R × R	75	97	16.5	77	23.4	174	19.5
R × L & L × L	28	32	28.2	31	41.9	63	34.9
R × L	24	28	28.6	25	48.0	53	37.7
R♀ × L♂	9	10	40.0	8	62.5	18	50.0
L♀ × R♂	15	18	22.2	17	41.2	35	31.4
L × L	4	4	25.0	6	16.7	10	20.0
TOTAL	103	129		108		237	

TABLE 7

Needle-threading incidence among offspring from different types of matings

TYPE OF MATING	SIBSHIPS	SONS		DAUGHTERS		TOTAL	
		n	% L	*n*	% L	*n*	% L
R × R	79	103	17.5	82	19.5	185	18.4
R × L & L × L	24	26	23.1	26	42.3	52	32.7
R × L	21	24	20.8	22	45.5	46	32.6
R♀ × L♂	7	8	25.0	6	50.0	14	35.7
L♀ × R♂	14	16	18.8	16	43.7	32	31.2
L × L	3	2	50.0	4	25.0	6	33.3
TOTAL	103	129		108		237	

sets of parents and their children are included. These results confirm the influence of heredity on handedness (Jordan, '11, '14; Hurst, '12; Ramaley, '13; Chamberlain, '28; Rife, '40). All agree in finding a higher incidence of left-handedness when at least one of the parents is

left-handed. The demonstration of some correlations between functional handedness and dermatoglyphic patterns, which were established by the end of the fifth month of fetal development (Cromwell and Rife, '42) suggest the existence of an anatomical basis for handedness. Rife ('43) also found associations characteristic of autosomal linkage between handedness and certain dermatoglyphic patterns.

TABLE 8

Handedness (all criteria except threading) among offspring from different types of mating

TYPE OF MATING	SIBSHIPS	SONS		DAUGHTERS		TOTAL	
		n	% L	*n*	% L	*n*	% L
R × R	92	115	11.3	94	13.8	209	12.4
R × L & L × L	11	14	28.6	14	28.6	28	28.6
R × L	10	12	33.3	12	33.3	24	33.3
R♀ × L♂	6	8	37.5	6	50.0	14	42.8
L♀ × R♂	4	4	25.0	6	16.7	10	20.0
L × L	1	2	0.0	2	0.0	4	0.0
TOTAL	103	129		108		237	

The data from twins are of particular interest because in identical twins with the same genotype one may be right-handed and the other left-handed (Rife, '40). Furthermore, the intrapair variation in fraternal twins is the same as that in identical twins (Wilson and Jones, '32; Rife, '40), and left-handedness in the twin population, including both types of twins, is more frequent than in the single-born population. The distribution of handedness in both fraternal and identical twins is not significantly different from what would be expected on a random basis; that is, with $a = f(R)$, the frequency of right-handedness, and $B = f(L)$, the frequency of left-handedness, the distribution equals $a^2(R\text{-}R) + 2ab(R\text{-}L) + b^2(L\text{-}L)$ (see table 9). Thus, the information from twins alone might suggest that prenatal environmental influences are solely responsible for handedness. However, Rife ('40, '50) has shown that R-L pairs of twins of both types have a higher frequency of L sibs and parents than R-R pairs, and, of course, prenatal environmental does not explain satisfactorily the greater frequency of right-handedness in the population.

Some of the earlier authors (*e. g.*, Jordan, '11, '14, and Ramaley, '13) postulated that left-handedness was inherited as a simple Mendelian recessive trait, an idea which has persisted in the literature (Wile, '42; Gillin, '48). However, the situation clearly is not so simple, for the R-L discordance in identical twins and the production of right-handed children from L × L parents suffice to disprove it. Rife, after suggesting ('40) that handedness was a quantitative trait which could not be explained on a single gene pair basis, returned ('50, '51) to a single gene mechanism with the heterozygotes, however, quite labile so that they may become right-handed, or ambidextrous, or left-handed, but with the homozygotes fixed as to the dominant hand. With the

TABLE 9

Comparison of Rife's data on handedness in twins (1950) with values expected under Rife's theory and with a random distribution

	MONOZYGOTIC				DIZYGOTIC			
	n	% 0	% *E* (RANDOM)	% *E* (RIFE'S THEORY)	*n*	% 0	% *E* (RANDOM)	% *E* (RIFE'S THEORY)
R-R	261	76.1	76.0	77.4	164	77.8	78.2	77.1
R-L	76	22.2	22.4	21.2	45	21.3	20.5	21.7
L-L	6	1.7	1.6	1.4	2	0.9	1.3	1.2
		f(R) = 87.2%				f(R) = 88.4%		
		f(L) = 12.8%				f(L) = 11.6%		

further assumptions that where both twins, fraternal or identical, are heterozygous, one will be right-handed and the other left-handed, and in dizygotic twins with only one heterozygous, that one will be left-handed in half of the cases and right-handed in the other half, Rife showed that this hypothesis fits his twin data (table 9). The greater frequency of left-handedness among twins was attributed to the fact that half of the heterozygous twins are phenotypically left-handed, whereas a majority of single-born heterozygotes become phenotypic right-handers. All facts considered, this theory is more satisfactory than a random distribution of handedness in twins. However, the rather specialized assumptions somewhat vitiate the argument, since the handedness of the labile heterozygous twin is assumed to be firmly fixed prenatally and not further influenced by post-natal events, while the

single-born heterozygote has handedness determined post-natally. However, it can also be shown that this hypothesis fits the data for the single-born reasonably well (tables 10 and 11), a further argument in

TABLE 10

Gene frequency analysis of handedness in single born children

MATING	POSSIBLE GENOTYPES	FREQUENCY OF MATING	FREQUENCY OF HANDEDNESS IN CHILDREN R	L
R × R	RR × RR	p^4	p^4	
	RR × Rr	$2p^3q$	$\frac{3p^3q}{2}$	$\frac{p^3q}{2}$
	Rr × Rr	p^2q^2	$\frac{p^2q^2}{2}$	$\frac{p^2q^2}{2}$
TOTAL			$\frac{p^2}{2}(p+1)$	$\frac{p^2q}{2}$
R × L	RR × Rr	$2p^3q$	$\frac{3p^3q}{2}$	$\frac{p^3q}{2}$
	RR × rr	$2p^2q^2$	p^2q^2	p^2q^2
	Rr × Rr	$2p^2q^2$	p^2q^2	p^2q^2
	Rr × rr	$2pq^3$	$\frac{pq^3}{2}$	$\frac{3pq^3}{2}$
TOTAL			$\frac{pq}{2}(2p+1)$	$\frac{pq}{2}(2q+1)$
L × L	Rr × Rr	p^2q^2	$\frac{p^2q^2}{2}$	$\frac{p^2q^2}{2}$
	Rr × rr	$2pq^3$	$\frac{pq^3}{2}$	$\frac{3pq^3}{2}$
	rr × rr	q^4		q^4
TOTAL			$\frac{pq^2}{2}$	$\frac{q^2}{2}(q+1)$

R = gene for right-handedness
left-handedness

p = frequency of R
q = frequency of r

its favor. The fit is not exact ($\chi^2 = 19.43$ with 5 d.f. and $p < .01$ for Rife's 1940 data on 2,178 children), but this result is not surprising in view of the arbitrary assumptions. The greatest deviation appears in the R × L matings were the % L is lower than expected. However, this deviation is in accord with Rife's suggestion that a

majority of the single-born heterozygotes, rather than the 50% assumed here, become right-handed. It is clear that neither hereditary nor environmental factors alone suffice to account for the genesis of handedness. The discordance between identical twins proves the importance of environmental factors while the discordance between a left-handed child and his completely right-handed cultural and familial environment indicates the importance of innate factors in the development of handedness. Hence, the statement of Sir George Humphry in 1861 may still adequately state the situation: "I am driven, therefore, to

TABLE 11

Frequency of left-handedness in offspring from various types of matings

MATING	EXPECTED * (RIFE'S THEORY) % L	OBSERVED RIFE ('40) % L
R × R	6.0	7.6
R × L	31.0	24.3
L × L	56.0	54.5

* Assuming 50% of Rr are right-handed and 50% are left-handed and f(L) = 12.0% (the frequency assumed by Rife in his 1950 paper on twins).

the rather nice distinction, that, though the superiority [of the right hand] is acquired, the tendency to acquire the superiority is natural [i.e., hereditary]."

Lauterbach ('25) and Chamberlain ('28) reported a greater frequency of left-handed males than females, but Jordan ('14) found no significant differences. There are no significant differences between males and females in the present study for any of the traits shown (table 2). The apparent excess of left-handed women in table 6 is due to the somewhat greater, but not significant (table 2) frequency of women who thread a needle left-handed (tables 7 and 8).

The influence of heredity on the dominant eye is shown in table 12, from which it is clear that the frequency of dominance in the left eye is considerably higher when one or both of the parents also has the left eye dominant. Although various authors have referred to the dominant eye as an inborn or hereditary trait, often in relation to discussions of handedness, apparently no pedigrees have previously

been published. The exact genetic mechanism must await further study, but it is clear that a straightforward single gene hypothesis is not adequate to explain the results. Since ocular dominance is only established by about the age of three (Fink, '38), it is probable that both prenatal and postnatal environmental factors also play some role in its determination.

TABLE 12

Dominant eye among offspring from different types of matings

TYPE OF MATING	SIBSHIPS	SONS		DAUGHTERS		TOTAL	
		n	% L	*n*	% L	*n*	% L
R × R	56	75	22.7	56	25.0	131	23.7
R × L & L × L	47	54	46.3	52	46.2	106	46.2
R × L	36	42	40.5	40	47.5	82	43.9
R♀ × L♂	21	28	32.1	25	56.0	53	43.4
L♀ × R♂	15	14	57.1	15	33.3	29	44.8
L × L	11	12	66.7	12	41.7	24	54.2
TOTAL	103	129		108		237	

DISCUSSION

In view of the number of harmful conditions supposedly related to or attributable to left-handedness, to changed dominance, or to mixed dominance of eye and hand, it would seem desirable to investigate most carefully, with adequate controls, the actual relationships involved. Since many of the previous studies were undertaken with erroneous assumptions, particularly as to the relationship between ocular and manual dominance, new insight into such difficulties as stuttering and reading problems may be forthcoming.

Furthermore, while it is clear that heredity plays a role in the development of dominance of both eye and of hand, the mode of operation of these genes in the developing individual is not known, nor is it understood how dominance can be modified by environmental conditions.

The demonstration of the influence of heredity on the dominant eye adds still another to the list of inherited traits in man. Although it appears that a simple one-gene hypothesis will not adequately explain the data, further information from more extensive pedigrees and from twins may make possible the framing of a relatively simple genetic hypothesis. If so, this trait may then become very useful in the study

of human genetics, for ocular dominance is easily determined, and both types of dominance are so frequent that segregation will commonly occur within families under study.

SUMMARY

1. Ocular dominance is shown to be unrelated to visual acuity, and hence is probably a motor phenomenon rather than a sensory or perceptual phenomenon.
2. A close relationship exists among four tests of hand preference and one for the preferred foot.
3. There is essentially no relationship between ocular dominance and the dominant hand.
4. A higher incidence of left-handedness is found when one or both parents are left-handed, in agreement with previous studies. The modified single-gene hypothesis applied by Rife ('50) to twins is shown to apply also to the single-born.
5. In matings R × R for dominant eye, 23.7% of the children had the left eye dominant; in R × L, 43.9%; and in L × L, 54.2%, thus demonstrating the influence of heredity on this trait.

LITERATURE CITED

BERNER, G. E. AND D. E. BERNER 1953 Relation of ocular dominance, handedness, and the controlling eye in binocular vision. A. M. A. Archives of Ophthalm., *50*: 603-608.

CALLAN, P. N. 1881 Are we right-handed? Medical Record, *19*: 390.

CHAMBERLAIN, H. B. 1928 The inheritance of left-handedness. J. Heredity, *19*: 557-559.

CROMWELL, H. AND D. C. RIFE 1942 Dermatoglyphics in relation to functional handedness. Human Biol., *14*: 516-526.

FINK, W. H. 1938 The dominant eye—its clinical significance. Arch. Ophthalm., *19*: 555-583.

FROUDE, J. A. 1884 Thomas Carlyle: A History of his Life in London 1834-1881. Vol. 2. Longmans, Green, London.

GAHAGAN, L. 1933 Visual dominance-acuity relationships. J. General Psych., *9*: 455-459.

GILLIN, J. 1948 The Ways of Men. Appleton-Century, New York.

GOULD, G. M. 1908 Right-handedness and Left-handedness. J. B. Lippincott, Philadelphia.

HUMPHRY, G. M. 1861 The Human Foot and the Human Hand. Macmillan, Cambridge.

HURST, C. C. 1912 Mendelian heredity in man. Eugenics Rev., *4*(1): 1-25.

JORDAN, H. E. 1911 The inheritance of left-handedness. Amer. Breeder's Mag., *2*: 19-29; 113-124.

——— 1914 Hereditary left-handedness, with a note on twinning. J. Genetics, *4*: 67-81.

KRIMSKY, EMANUEL 1948 The Management of Binocular Imbalance. Lea and Febiger, Philadelphia.

KURODA, G. 1927 Observation on right- and left-eyed children. Psych. Abst., *1*: 72.

LAUTERBACH, C. E. 1925 Studies in twin resemblance. Genetics, *10*: 525-568.

LE CONTE, J. 1881 Sight. Appleton, New York.

MCANDREWS, L. F. 1935 Ocular dominance. Arch. Ophthalm., *13*: 449-455.

MILES, W. R. 1930 Ocular dominance in human adults. J. General Psych., *3*: 412-430.

MILLS, L. 1925 Eyedness and handedness. Amer. J. Ophthalm., *8*: 933-941.

PARSON, B. S. 1924 Lefthandedness. Macmillan, New York.

PYE-SMITH, P. H. 1871 On left-handedness. Guy's Hospital Reports, 3rd Series, *16*: 141.

RAMALEY, F. 1913 Inheritance of left-handedness. Amer. Nat., *47*: 730-738.

RIFE, D. C. 1940 Handedness, with special reference to twins. Genetics, *25*: 178-186.

——— 1943 Genetic interrelationships of dermatoglyphics and functional handedness. Genetics, *28*: 41-48.

——— 1950 An application of gene frequency analysis to the interpretation of data from twins. Human Biol., *22*: 136-145.

——— 1951 Heredity and handedness. Sci. Monthly, *73*: 188-191.

STEVENS, H. C. 1909 Review of Gould's "Right-handedness and left-handedness." Science, *30*: 182-184.

WALLS, G. L. 1951 Theory of ocular dominance. Arch. Ophthalm., *45*: 387-415.

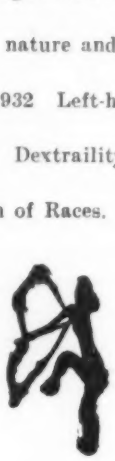
WILE, I. S. 1934 Handedness, Right and Left. Lathrop, Lee and Shepard, Boston.

——— 1942 Eye dominance; its nature and treatment. Arch. Ophthalm., *28*: 780-791.

WILSON, P. T. AND H. E. JONES 1932 Left-handedness in twins. Genetics, *17*: 560-571.

WOO, T. L. AND K. PEARSON 1927 Dextrality and sinistrality of hand and eye Biometrika, *19*: 165-199.

WOODRUFF, C. E. 1909 Expansion of Races. Rebman, New York.



PHYSIOLOGICAL REGULATIONS AND THE ORIGIN OF HUMAN TYPES[1]

BY CHARLES G. WILBER

Comparative Physiology Branch, Directorate of Medical Research, Army Chemical Center, Maryland

ANTHROPOLOGISTS are hard put to explain the origin of human racial types in a scientifically acceptable manner. Of late they have called on ecology for help and are using certain ecological postulates as explanations for morphological variations among races.

For example, it is suggested that men who inhabit and thrive in the cold regions of the world necessarily have stocky bodies and relatively short extremities and that those in the tropics are necessarily lean and long-legged (Coon, '54, '55). Such a view stems from an attempt to apply the generalizations of Bergman and of Allen to *Homo sapiens*. Bergmann's "rule" or generalization asserts that homeotherms from colder climates tend to have a larger body mass and consequently less relative surface areas than do related forms from warmer climates. Allen's rule states that in homeotherms there is a marked tendency toward decrease in size of extremities and appendages in colder climates (Allee *et al.*, '49).

One does not question the need for consideration of human ecological problems within the framework of principles which have proven sound in the light of animal experience. One must be aware, however, that ecological extrapolation from animals to man is fraught with danger. Before such extrapolations are warranted the investigator must be certain of affirmative answers to the following questions:

[1] Sincere gratitude is expressed to Professor William L. Straus, Jr., and Professor George F. Carter, of the Johns Hopkins University, who read the manuscript critically and suggested important changes. It is emphasized, however, that all deficiencies in the final product are the author's.

a. Are the assumptions to be used based on sound ecological and physiological data for animals?
b. Are the conclusions derived in accord with the facts of human physiology?
c. Are the specified ecological forces which influence animals really affecting man in an identical manner?

The facts force me to say, "no," to each of the above questions when they refer to man and the postulates or so-called "rules" of Bergmann and Allen. A demonstration of the invalidity of these concepts in human ecology is the theme of this paper.

Do these rules apply to animals? Many examples are cited in the ecological literature to support the views of Bergmann and Allen. Rabbits are said to have leaner and longer ears as we progress southward from the polar regions; however, different species of rabbits are involved. The barren ground caribou is given as larger than the more southern forest species. The extensive migrations back and forth of these animals should not be ignored and the greater severity of cold in the subarctic forests is a pertinent factor. The penguins of the extreme south are said to be larger than those nearer the equator. But, large and small penguins are found together in some antarctic areas. In all these examples when one examines the basic data, the differences in size and weight are relatively trivial and do not in any clear manner give evidence of overwhelming cold survival value to the heavier forms (Scholander, '55).

Of basic importance to the acceptability of these "rules" is the assumption that in animals heat production is a function of mass and heat dissipation a simple function of surface area. The tenuous nature of the latter assumption is clear from a careful examination of temperature regulating mechanisms in mammals.

I propose to refer to that school of thought which explains the origin of human racial types in terms of Allen's and Bergmann's postulates as "climatic determinists." It is my contention that their stand is based on inadequate data improperly interpreted. As I view human ecology, one constant factor repeats itself: Man, from his earliest origins, has not responded to his environment in a willy-nilly fashion but has rather done everything possible to control and shape that environment to conform to his ideas of comfort and convenience.

The climatic determinists ordinarily suggest that adipose tissue in animals serves as a dead, insulating blanket which inhibits effective heat

exchange between the animal and its environment. Witness the so-called rule of Rensch which attempts to explain fat distribution in certain species on the basis of heat transfer "needs" of the animal. These generalizations show great inventiveness and may have a germ of truth but unfortunately are not completely in accord with physiological fact. Adipose tissue is not a dead, inactive thing, but is quite active metabolically (Schoenheimer, '46). For metabolic purposes the capillary bed of fat tissue is comparatively richer than that of muscle (Wertheimer and Shapiro, '48). The blood vessels are innervated by sympathetic nerve fibers. One wonders, then, what stimulus is adequate to induce the deposition of fat over all the body of cold-dwelling mammals and only in the tail or buttocks of certain dwellers in warm areas. From the physiological point of view climate does not impress one as adequate.

One is told that the seals of the Arctic Ocean have a layer of insulating blubber; but, the seals and sea lions from the warm waters of California are not particularly skinny; nor is the Florida manatee a striking example of spare build.

In the cold, homeotherms adjust for survival by increasing metabolic rate, by increasing insulation, by selecting a favorable microclimate, and by maintaining cold extremities to reduce heat loss from the core (Scholander, '55). For example, the Eskimo husky dog and the Arctic fox have a critical temperature of at least —40° C. The critical temperature, as you know, is the lowest air temperature at which an animal can maintain a resting or basal metabolic rate. This ability to remain in a resting metabolic state at very low temperatures is a result of increased insulating capacity of the fur which in these species is fluffed up in the cold. The typically Arctic lemming has a critical temperature around +10° C., but this species and others like it select suitable microclimates near freezing, and many build warm nests. In these cases behavior patterns and not morphological ones make for survival in cold. Caribou and sea gulls conserve body heat by maintaining cold extremities. The caribou on cold days keeps its thin legs at +10° C., or lower. Arctic gulls have been kept with their feet in ice water for several hours and the basal metabolic rate goes up only about 1.5% (Scholander *et al.*, '50). The gull preserves body heat by holding the tissue temperature of the legs near zero. Moreover, cellular adaptations occur which permit portions of nerve axons in these cold parts to conduct effectively at depressed temperatures (Chatfield *et al.*, '53).

Some arctic and subarctic dwellers meet the enormous heat losses by increasing metabolic rate for prolonged periods. The red squirrel of Central Alaska does just that, and it is not a particularly globular type of homeotherm but it seems well established in its northern neighborhood.

There is no clear-cut physiological evidence that homeotherms tend to a globular form with reduced extremities in the face of cold exposure. There is a wealth of evidence that adapted homeotherms in the cold decrease heat loss by increasing insulation and by maintaining cold extremities; some turn up the thermostat, as it were, and increase heat production. On the basis of our present knowledge the rules of Bergmann and Allen appear to be of historical or descriptive interest only and certainly are not valid generalizations for animals in the cold.

In the heat, the views of the climatic determinists are also open to question. For example, "Neither the ratio of surface area to body weight, nor the ratio of surface area to the two-thirds power of body weight, showed a significant difference between Jersey cattle and Sindhi-Jersey crosses, although the latter have appreciably greater heat resistance than do the former" (McDowell *et al.*, '53). In other words, heat tolerance could not be attributed to greater proportional surface, large dewlap or other morphological peculiarities.

Need one mention that the hippopotamus, rhinoceros, and elephant are built on the roly-poly, globular pattern, but are well entrenched in their tropical environments? The camel is adapted to its normal hot environment; not by reason of its morphology but because its tissues can withstand elevated temperatures for long periods. In order to conserve water, evaporative cooling is depressed to a minimum during water shortage in the camel; the rectal temperature may rise from 34.2 to 40.7° C. during the day with no harm to the beast (Kleiber, '56). It would seem that readjustment of cellular mechanisms and not alteration of body form is the key factor in animal adaptations to heat. Birds which live in the desert adapt in a similar fashion and many avian species respond to heat by reduced metabolic heat production (Gelineo, '55).

Mayr ('56) re-emphasizes the fact that the so-called rules of Bergmann and Allen are "purely empirical generalizations describing parallelisms between morphological variation and physiogeographic features." He admits that too many writers have elevated these purely descriptive comments to the status of laws. In reality these rules have

"only statistical validity." It is good to know that competent zoologists appreciate this fact. However, the point at issue remains: Some anthropologists and sociologists are using these descriptive generalizations to explain human racial variations as if they were laws having causal value. Such usage is misleading and unjustified.

Do these rules apply to man? If the contentions of the climatic determinists are valid, one must visualize the historical Eskimo as a wretched creature with teeth and bones rattling from cold. Then in a good Lamarckian fashion he should have shortened his legs and arms and inflated his body to resemble "Mr. Five by Five." In this way he would produce much heat and lose little of it and thus be adapted to the severe Arctic. This globular form would be transmitted to his children and his children's children. Unfortuately for this view, the Eskimo never read about Bergmann's or Allen's rule; so they cheated. Instead of shivering they manufactured the warmest type of clothing known to man and devised homes which maintained rooms at tropical temperatures. On the trail their bodies, with exception to face and sometimes hands, were at temperatures of 80–90° F. At home they lived in sod or snow shelters with interior temperatures up to 100° F., so hot in fact that these people usually rested stripped to the waist (Stefansson, '21). Under such conditions the stimulus of climate is a tropical one which should have made them tall and skinny. In the face of a tropical microclimate (which is of course the real stimulus acting on the Eskimo) this race is held, by the climatic determinists, to develop morphological adaptations of positive survival value in the cold.

Jenness ('23) has pointed out that, with respect to all Eskimos, "The fur clothing in which they are habitually enveloped gives them an exaggerated appearance of corpulence, whereas in reality they incline towards slenderness, the body tapering a little below the broad shoulders."

The Eskimos living at Point Barrow during the last century showed no evidence of spherical build. The following data illustrate this fact:

	Males	*Females*
Average weight, lbs.	153.5	135.7
Average height	5′ 3″	4′ 11″

These results are from Ray's (1885) report of his expedition to Point Barrow between 1881 and 1883.

The only real cold people in the world were the aborigines of Tierra

del Fuego and of Australia. The former were never studied from the metabolic point of view. However, Darwin and others have described them as thin, small people who lived, worked and rested stark naked even in severe snow storms. The Australian aborigines in their native state are able to rest naked at 0° C. while maintaining a basal heat production (Hicks *et al.*, '34). They are a small, skinny people whose build, according to climatic determinists, should have evolved in response to heat, whereas they show remarkable physiological adaptation to cold. If any groups of men should show a globular form with relatively short extremities, it is the Australian aborigine and the Tierra del Fuegians. The fact that they show opposite of the expected response to the climatic determinist rules illustrates the danger of explaining human racial morphology in terms of Bergman's and Allen's generalizations.

We are quite ignorant of the physiological adaptations to cold in the Fuegians. The Australian aborigine, on the other hand, has been studied metabolically. He shows physiological adaptations characteristic of Arctic animals: Extremely active control of cutaneous circulation which results in maintenance of cold skin and extremities in decreased environmental temperatures with consequent saving of heat (Wulsin, '49). These adaptations are functional and do not involve changes in exterior body form. They are the only clear-cut biological adaptations of man to cold that we know.

Bates ('53) contends that, "It is easy to assume that, since the races show a pattern of geographical distribution, they represent adaptation to different geographical environments; and, with a certain amount of ingenuity, all sorts of adaptive traits can be described." However, under careful study these schemes usually disintegrate. As a rule, diagnostic, structural peculiarities of human groups show no evidence of being adaptive; they may be correlated with differences in function or behavior and these latter are certainly adaptive. The solution of this problem lies in the experimental approach to racial matters and not in the use of descriptive generalizations as though they were causal agents in the formation of races.

Man a tropical mammal: Man in all his adaptations is ordinarily a tropical mammal. (The responses of the Australian native to cold are an exception). He responds to cold by keeping his extremities warm (contrary to adaptation in true Arctic homeotherms which maintain cold extremities and thus conserve heat), a process wasteful of heat

and characteristic of a tropical animal. He adapts to heat by measureable physiological adjustments: Increased volume of sweat, greater dilution of sweat, hemodilution, decrease in heart rate during activity. These adjustments make it possible for man to live and work effectively in hot climates without the aid of artifacts. There are few proven physiological adaptations of man to the cold. In the face of low ambient temperatures, man either adds clothing, heats his dwelling, or combines the two. Naked, he is usually helpless in the cold; naked, he adapts to the heat in an effective manner.

Newman ('56) has outlined the physiological adjustment that man makes to cold. It is true that the Eskimo is better able to live in the cold than is the Negro. But the Eskimo handles the problem by a typical tropical response: the maintenance of warm extremities. This in turn requires high caloric intake and expenditure, a fact which denies the Eskimo as an example of a heat conserving mechanism operating in the cold.

SUMMARY

This brief and rapid survey does not postulate that climate is without effect on man. At another time the ecological effect of this variable on man will be discussed. This presentation attempted to show in a sketchy fashion the following:

1. The rules of Bergmann and Allen find little support *as causal agents* in modern studies of temperature regulation in homeotherms.

2. The various formal examples often cited in favor of these ecological generalizations do not support the case of the climatic determinists. One is forced to conclude that the rules just do not apply causally to animals.

3. In man the ecological forces supposed to be acting are not doing so; Eskimos were not cold, the skinny aboriginal Australians were.

4. The rules of Bergmann and Allen have no causal role in the formation of racial differences in man. Such use of these rules on the part of some anthropologists is a source of misinformation and confusion.

5. Some human groups have met the demands of severe climate by technological and behavioral adjustments; the Eskimos are an example. Others have developed specific heat-conserving functional changes, with no gross morphological changes; the Australian aborigines are an example.

LITERATURE CITED

ALLEE, W. C., A. E. EMERSON, O. PARK, T. PARK AND K. P. SCHMIDT 1949 Principles of Animal Ecology. Saunders, Philadelphia.

BATES, M. 1953 Human Ecology. *In* Anthropology Today. Ed. A. L. Kroeber. Pp. 700-713. U. of Chicago Press, Chicago.

CHATFIELD, P. O., C. P. LYMAN AND L. IRVING 1953 Physiological adaptation to cold of peripheral nerve in the leg of the herring gull (*Larus argentatus*). Amer. J. Physiol., *172*: 639-644.

COON, C. S. 1954 The story of Man. Knopf, New York.

——— 1955 Some problems of human variability and natural selection in climate and culture. Amer. Nat., *89*: 257-280.

GELINEO, S. 1955 Température d'adaptation et production de chaleur chez les oiseaux de petite taille. Arch. Sci. Physiol., *9*: 225-243.

HICKS, C. S., N. O. MOORE, E. ELDRIDGE 1934 The respiratory exchange of the Australian Aborigine. Australian J. Exp. Biol. Med. Sci., *12*: 79-89.

JENNESS, D. 1923 Physical Characteristics of the Copper Eskimo. Rpt. Canadian Arctic Exped., Vol. XII, Part B, 89 pp. Ottawa.

KLEIBER, M. 1956 Energy metabolism. Ann. Rev. Physiol., *18*: 35-52.

MAYR, E. 1956 Geographical character gradients and climatic adaptation. Evolution, *10*: 105-108.

MCDOWELL, R. E., D. H. K. LEE AND M. F. FOHRMAN 1953 The relationship of surface area to heat tolerance in Jerseys and Sindhi-Jersey (F_1) crossbred cows. J. Animal Sci., *12*: 747-756.

NEWMAN, M. T. 1956 Adaptation of man to cold climates. Evolution, *10*: 101-105.

RAY, P. H. 1885 Report of the International Polar Expedition. Government Printing Office. Washington.

SCHOENHEIMER, R. 1946 The Dynamic State of Body Constituents. Harvard, Cambridge.

SCHOLANDER, P. F. 1955 Evolution of climatic adaptation in homeotherms. Evolution, *9*: 15-26.

SCHOLANDER, P. F., R. HOCK, V. WALTERS AND L. IRVING 1950 Adaptation to cold in arctic and tropical mammals and birds in relation to body temperature, insulation, and basal metabolic rate. Biol. Bull., *99*: 259-271.

STEFANSSON, V. 1921 The Friendly Arctic. Macmillan, New York.

WERTHEIMER, E. AND B. SHAPIRO 1948 The physiology of adipose tissue. Physiol. Rev., *28*: 451-464.

WULSIN, F. R. 1949 Adaptations to climate among non-European peoples. *In* Physiology of Heat Regulation. Ed. L. H. Newburgh. Saunders, Philadelphia. Pp. 3-69.

ROENTGENOGRAMMETRIC DETERMINATIONS OF BODY COMPOSITION[1]

BY STANLEY MARION GARN

Fels Research Institute
Antioch College, Yellow Springs, Ohio

INTRODUCTION

THE technique of measuring the fat-plus-skin shadow on suitably light soft-tissue x-rays was introduced by H. C. Stuart in 1940 (Stuart, Hill and Shaw, '40). Since that time it has been widely used, primarily in America (Reynolds, '51), and to some extent in England (Tanner, '55) and in Spain (Suarez, '53). There are, at the time of this writing, some 50 published studies dealing with the thickness of the subcutaneous fat on various parts of the body and in both sexes. The age range of subjects so studied encompasses the entire life span, from earliest infancy through the seventh decade.

Investigations involving the fat-plus-skin shadow have varied in their purpose. Many of the earlier studies were essentially normative. More recently, the problem of configuration has come into prominence. And, the range of problems has included the stability of individual fat patterns, changes in subcutaneous fat during weight loss, the relation between fat and growth progress, the quantitative assessment of obesity, and the relationship between x-ray and pinch-caliper measurements of superficial fat.

However, it is evident that the thickness of the subcutaneous fat layer, or "outer fat" is at least roughly proportional to the total weight of fat. For one thing, weight and fat show moderate to high correla-

[1] This work described herein was supported in part by Contract No. AF 18 (600) 1566 with the Air Research and Development Command and research grant M-1260, United States Public Health Service, National Institute of Mental Health.

tions, when the "best" fat sites are considered (*cf.* Garn, '57a, '57b). Again, the thickness of the subcutaneous fat is inversely related to specific gravity. Without endorsing the oft-stated assumption that outer and inner fat are equal—a relationship manifestly impossible in obese subjects—it is nevertheless obvious that people with thicker subcutaneous fat deposits are fatter and weigh more. This leads to the possibility of estimating the *weight* of fat from the *thickness* of selected fat sites.

The possibility of estimating the weight-of-fat (and the fat-free weight as well) from fat thickness and gross weight was explored in a preliminary study (Garn and Harper, '55) wherein the group means appeared to be reasonable, in comparison to other published data. Further, individual estimates of the weight of fat, based on fat-thickness data, were compared to a biochemical index of obesity, and it was shown that the biochemical index not infrequently yielded palpably improbable estimates (Garn and Clark, '55). However, a critical analysis of the method and consideration of findings derived therefrom, were premature at that time.

More recently we have been able to extend these studies to a larger number of individuals (251), including both sexes and a carefully selected series of young adult males with a very narrow age range. The results obtained appear to be most encouraging both in terms of the immediate findings, and toward further applications of the method. The roentgenogrammetric method has the particular advantage of being capable of providing information not only on fat (and therefore the fat-free mass), but also of providing estimates of muscle mass and skeletal weight as well.

METHODS AND MATERIALS

The present study is based upon standardized soft-tissue x-rays of 251 adult men and women.

The first group of subjects consisted of 94 American-born white women, all mothers of children in the Fels Longitudinal Series. Most of them were occupied as "housewives" but approximately 33% were engaged in clerical, secretarial or managerial jobs away from home. The age range was 20 to 64 years, and the means for age, stature, and weight were 37.2 years, 162.3 cm, and 60.4 kg. Stature was closely comparable to the mean height of WAAF basic trainees (Daniels, Myers and Worrall, '53), the Minnesota volunteers studied by Skerlj, Brožek and Hunt ('53) and the standard statures assumed by Behnke ('53,

p. 1107). Average weight agreed closely with that of the Minnesota women, and with the 35 year old group-standard given by Behnke.

The second group of subjects included 75 adult white American-born men, all of them Fels fathers, and like the mothers, primarily of Northwest European extraction. With an age range identical to that for the women, and a very slightly higher mean age (40.3 years), the means for stature and weight were 176.3 cm and 76.0 kg. Mean stature was within 1.0 cm of the Behnke standard, and of the mean for the older Minnesota men tabulated by Brožek ('52). In average weight the men were 2 kg above the Behnke value for comparable age and close to the groups summarized by Brožek in tables 2 and 5 of his paper. About half of these Ohio male subjects were engaged in farming, skilled labor, and other tasks requiring considerable physical activity.

The third group consisted of 82 American-born white male college students, selected to provide a narrow age range of 21.0 to 22.9 years: the mean age was 21.7 years. In mean stature (178.3 cm), and weight (72.6 kg), they were above the Army medians reported by Newman ('56). Only a few of the students were regularly active in college athletics but several engaged in semi-pro sports away from college. Since approximately 35% of them were of Southern or Southeastern European ancestry, the student sample was tabulated separately from the Ohio males.

The soft-tissue x-rays were taken at a 6 foot tube-to-film distance, at 18 milliampere seconds, and at 40–80 Peak Kilovolts, depending upon part thickness. Fast film, intensifying screens and normal development were used throughout. The circle of irradiation was reduced to a minimum, through the use of a double-diaphragm cone. Even without special gonadal shielding introduced in these studies in 1955 (Garn, '57a and Garn, Sontag and Silverman, '57) gonadal radiation was far *below* 0.1 r (100 mr) (which is approximately the yearly natural background dosage (*cf.* Neher, '57). The fat-plus-skin shadows on the radiographic films were measured at right angles to the skin surface, using ground-tip vernier calipers.

Individual estimates of body fat were based on mid-trochanteric fat (T_2) for males and iliac crest fat (I_1) for females, by using constants appropriate to the group in question. These particular sites were selected as having (1) the greatest communality with other measured fat sites, and (2) highest correlations with weight (*cf.* Garn, '54; Garn and Clark, '55; Garn, '57c). Although we had intended to base fat-

weight estimates on multiple fat sites, a detailed comparison of equations based on single and multiple predictions showed no great improvement in predictive efficiency when more than one site was included (Garn, '57b). Accordingly, the simpler procedure was used throughout even though data on 8 other fat sites were available.

The technique of estimating individual weight-of-fat values from the regression of weight on fat may be considered in terms of the simple prediction equation

$$y = ax + b$$

wherein weight (y) bears a nearly straightline relationship to the fat thickness (x), with a slope defined by the constant (a).

As Behnke ('53) has pointed out, weight may be considered as having two components, the fat-free weight (here equivalent to b) and the weight of fat (here equivalent to ax).

Hence, if b is subtracted from both sides of the equation,

$$y' = ax$$

and ax equals the weight of fat.

Now the constant a is easily determined from the values of r, σy and σx since

$$a = r\frac{\sigma y}{\sigma x}x$$

as described in Peters and Van Voorhis ('40).

Thus, if the individual value of fat (x) is multiplied by the constant (a), an estimate for the individual's weight of fat is obtained.

And, as should be obvious, since $y - y'$ equals the fat-free weight, subtracting ax from the individual's gross weight yields an estimate of his lean or fat-free weight.[2]

The utility of this method depends upon several assumptions, one being linearity of the fat-weight relationships and another being a lack of correlation between gross size and fat. Both assumptions were shown to hold within the limits of the present data. Again, the success of this method depends upon the relative independence of the fat-free weight from the weight of fat. This was shown, not only by the

[2] It will be noted that the estimated fat-free weight is, in every case, an *individual* estimate obtained by subtracting ax from gross weight, and not the group intercept b.

correlation method, but also by replicate estimates on individuals who had gained or lost considerable fat. A further documentation of this point appears in the next section.

It is important to point out that the findings given in this paper, and in particular the constants used in the weight-of-fat estimates should not be applied to other groups without due caution. Whereas the constants necessarily fit the data, they are ultimately derived from r and this in turn is subject to sampling error. Finally, the technique is not applicable to individuals who have rapidly lost weight, or to others in whom the normal relationship between weight and subcutaneous fat thickness has been disturbed as during semi-starvation (Garn and Brožek, '56) or in lipo-distrophies.

FINDINGS

Estimates of the weight of fat were calculated upon an individual basis, using trochanteric fat (T_2) for the male series, and iliac crest fat (I_1) for the 94 females. The constants 0.76, 0.81 and 0.72 were employed for the student series, the Ohio male series, and the Ohio female series respectively.

As shown in table 1, all three fat distributions were markedly and positively skewed, in the manner characteristic of fat. Skewness in the two male series was effectively of the same type. However, the female fat values were even more positively skewed, and the distribution was flatter. Thus, there is very good reason to avoid the mean and the standard deviation when reporting weight-of-fat data.[3]

As might be expected, the Ohio males (who were somewhat heavier than the students) proved fatter, with a median weight of fat of 12.7 kg, as contrasted to 9.0 kg for the college males, a difference almost equal to the difference in weights. Nearly 60% of the students had 10.0 kg of fat or less, as compared with approximately 30% of the Ohio men. The women, in turn, proved fatter than either male group, though only slightly more so than their husbands, and 4.5 kg more than the college males. For all three groups the lowest 5%, or truly lean individuals, possessed 6 kg of fat or less. But the "obese" category, or upper 5% included those Ohio women in excess of 30 kg of fat, the Ohio men who had 23 kg of fat or more, and the students whose weight

[3] With variations in skewness, two very dissimilar distributions may have the same mean and two rather similar distributions may have different means.

of fat exceeded 25.5 kg (these values were obtained from the percentile distributions before grouping into class intervals as shown in table 1).

Fat-free weights were calculated, again on an individual basis, by subtracting the estimated weight of fat from gross weight. Here, one would not anticipate a large difference between the two male series (barring accidents of sampling) and this expectancy was confirmed

TABLE 1

Distribution of estimated fat weights

FAT WEIGHT (Kg)	94 OHIO FEMALES		74 OHIO MALES		82 COLLEGE MALES	
	No.	%	No.	%	No.	%
2.5– 4.9	4	4.3	4	5.4	6	7.3
5.0– 7.4	17	18.1	8	10.8	23	28.1
7.5– 9.9	15	16.0	10	13.5	19	23.2
10.0–12.4	8	8.5	14	18.9	11	13.4
12.5–14.9	8	8.5	11	14.9	6	7.3
15.0–17.4	2	2.1	9	12.2	4	4.9
17.5–19.9	8	8.5	9	12.2	4	4.9
20.0–22.4	8	8.5	4	5.4	3	3.7
22.5–24.9	6	6.4	3	4.1	1	1.2
25.0–27.4	5	5.3	1	1.4	3	3.7
27.5–29.9	6	6.4	1	1.4	—	—
30.0–32.4	5	5.3	—	—	1	1.2
32.5–34.9	1	1.1	—	—	—	—
35.0–37.4	1	1.1	—	—	1	1.2
MEAN	16.0		13.4		11.04	
MEDIAN	13.5		12.7		9.0	

(table 2). The median fat-free weight was 58.2 kg for the Ohio males, and 62.5 kg for the taller and younger students. However, one subgroup in the Ohio series consisting of farmers (see above) had a median fat-free weight of 68.5 kg. The women, in turn, had far lower fat-free weights, with a median at 42.3 kg, approximately 66% of the median male value. Although there was a fair overlap between the women and the men in respect to the fat-free weight, only one woman actually equalled the combined male median value. This finding is consistent with other data and estimates of fat-free weights (*cf.* Behnke, '53, Edelman *et al.*, '52).

It is of some interest to consider the range of fat and fat-free weights

as an indication of the variability of the several body compartments. The range of fat weights was approximately 2 to 36 kg; the most obese woman was 18 times as fat as the leanest subject. On the other hand, the range of fat-free weight was 30 to 62 kg for women (a ratio of 2:1), and the comparable ratio for the males was 1.7:1. Fat variability thus appears to be extremely great, and if fat is not "the most variable tissue," certainly it is an excellent contender for that title.

TABLE 2

Distribution of fat-free weights

ESTIMATED FAT-FREE WEIGHT (Kg)	94 OHIO WOMEN 20–60		74 OHIO MEN 20–60		82 COLLEGE MEN 21–22	
	No.	%	No.	%	No.	%
28.0–31.9	2	2.1	—	—	—	—
32.0–35.9	4	4.3	—	—	—	—
36.0–39.9	16	17.0	—	—	—	—
40.0–43.9	17	18.1	—	—	—	—
44.0–47.9	32	34.0	—	—	2	2.4
48.0–51.9	14	14.9	6	8.1	3	3.7
52.0–55.9	7	7.4	5	6.8	11	13.4
56.0–59.9	1	1.1	16	21.6	20	24.4
60.0–63.9	1	1.1	20	27.0	22	26.8
64.0–67.9	—	—	9	12.2	10	12.2
68.0–71.9	—	—	8	10.8	7	8.5
72.0–75.9	—	—	5	6.8	6	7.3
76.0–79.9	—	—	5	6.8	—	—
80.0–83.9	—	—	—	—	—	—
84.0–87.9	—	—	—	—	1	1.2
MEAN	44.6		62.4		61.5	
MEDIAN	42.3		58.2		62.5	

The data here presented further testify to the greater relative fatness of the female. Though not much fatter than the males in absolute terms, expressed either in relationship to total weight or to the fat-free weight the female is proportionately fatter. Using the more common computation, fat as a percentage of gross weight, the median percentage of fat for males was 16.8% as contrasted with 23.7% for their wives: the frequency distribution shows the extent of sexual dimorphism in this respect (figure 1). However, expressing fat in relation to the fat-free weight more effectively portrays the sex difference and singles out

those individuals whose weight of fat equals or exceeds their fat-free weight. As shown in figure 2, there are a few phenomenal individuals with a fat to fat-free ratio of 100 or even more!

Sorting the fat-free weights in respect to stature served to check whether the present method effectively takes stature into account. As

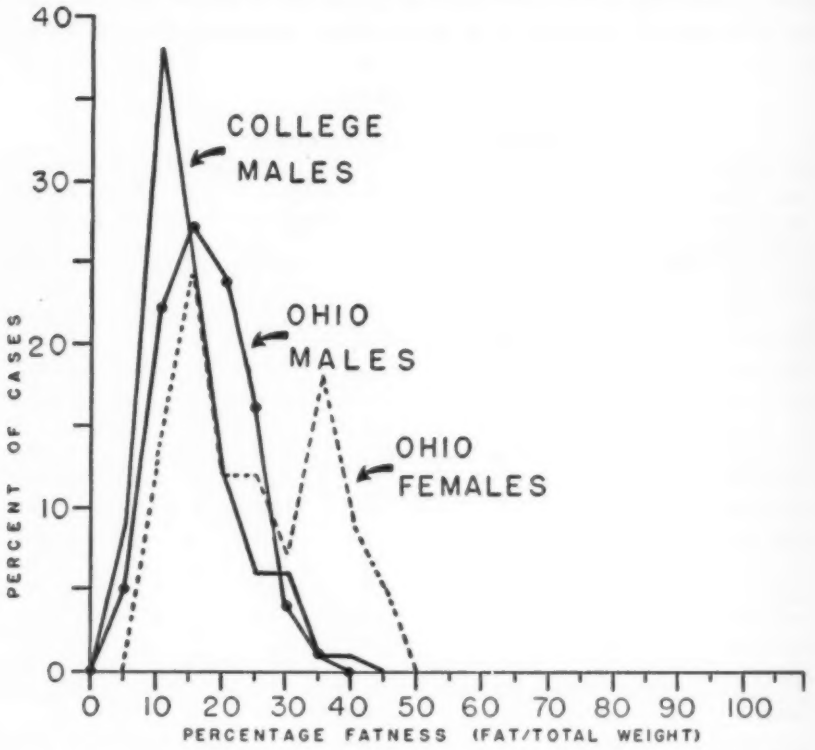


FIG. 1. FAT EXPRESSED AS A PERCENTAGE OF GROSS WEIGHT: THE TWO MALE SERIES ARE THE SAME FORM AND OF EQUAL SKEWNESS WHEREAS PERCENTAGE OF FAT IN FEMALES SHOWS SKEWNESS OF A MORE EXTREME TYPE AND BIMODALITY.

shown in table 3, there is a progression of fat-free weights from the first to the fourth stature quartile in each group. The shortest women had a low median fat-free weight (39.9 kg), while the median fat-free weight for the fourth stature quartile was 47.9 kg. In the Ohio males a similar upward trend was evident: the median fat-free weight rose from 56.2 kg in the first stature quartile to 65.6 kg in the fourth. And

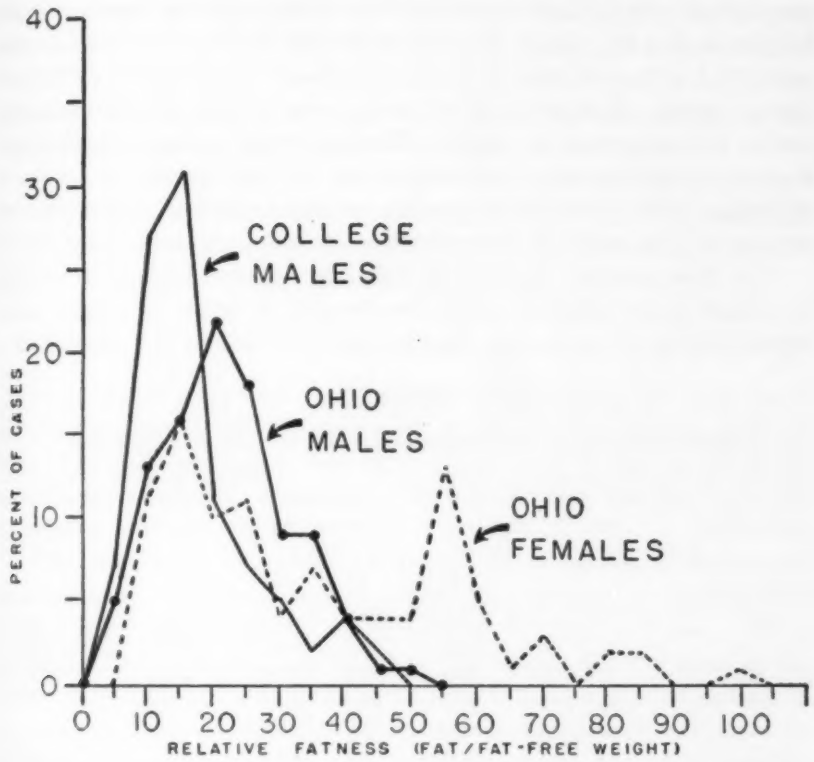


FIG. 2. FAT EXPRESSED AS A PERCENTAGE OF THE FAT-FREE WEIGHT. HERE THE SEX DIFFERENCE IS MADE MORE APPARENT AND THE EXTREMELY OBESE INDIVIDUALS IN WHOM THE WEIGHT OF FAT EQUALS OR EXCEEDS THE FAT-FREE WEIGHT ARE MORE PERFECTLY DESIGNATED (see text).

TABLE 3

Fat-free weight by stature quartiles

	OHIO WOMEN 20–60		OHIO MEN 20–60		COLLEGE MEN 21–22	
STATURE QUARTILE	STATURE (cm)	FAT-FREE WEIGHT (kg)	STATURE (cm)	FAT-FREE WEIGHT (kg)	STATURE (cm)	FAT-FREE WEIGHT (kg)
q 1	157.0	39.9	169.9	56.2	170.6	56.1
q 2	160.9	45.1	173.7	60.2	176.6	56.5
q 3	164.2	45.8	177.8	60.2	180.7	59.9
q 4	169.2	47.9	182.9	65.6	185.4	64.4

the student group almost duplicated this trend, with an increase from 56.1 kg to 64.4 kg. Since the median fat-free weight, equivalent to the value of b (the y intercept of x) is obviously different for different stature groups, the possibility of using values of a specific to each stature grouping was considered. However, while preliminary analyses showed slightly improved estimates of the fat-free weight at extremes of stature, when using stature-specific constants, the size of the present samples was too small to compute definitive stature-specific values of a.

The final problem was that of reliability of the method, primarily in respect to the estimates of fat-free weight. Granted that immediate reproducibility of results may be high (limited only by the standardiza-

TABLE 4

Replicability of fat-free weights after weight gain or weight loss

SUBJECT NO.	SEX	WEIGHT (kg)		ESTIMATED FAT-FREE WEIGHT (kg)		WEIGHT CHANGE (kg)	APPARENT DIFFERENCE (kg)
		1	2	1	2		
0277	f	79.2	68.9	37.7	35.3	—10.3	—2.4
1	f	71.4	58.6	47.1	46.1	—12.8	—1.0
27	f	58.0	59.7	47.7	47.1	1.7	—0.6
112	m	69.4	73.2	54.5	57.6	3.8	3.1
20	m	92.9	84.8	69.9	68.9	—8.1	—1.0
0371	m	78.3	72.7	67.1	66.1	—5.6	—1.0
0245	m	68.6	75.9	62.3	64.7	7.3	2.4
45	m	94.1	89.1	72.7	71.3	—5.0	—1.5
46	m	81.6	90.1	61.1	61.6	10.5	0.5
47	m	77.5	88.0	63.2	61.6	10.5	—1.5

tion of the x-ray poses and precision of the fat measurements), how consistent are the estimates of fat-free weight when fat itself increases or decreases? The limiting assumption here is that the fat-free weight is reasonably stable within normal limits of weight variability.

As shown in table 4, the present technique appears to yield fat-free weight estimates reproducible within ± 2 kg, or 2-5% of gross weight. Using a series of 10 adult subjects who had gained or lost up to 12 kg, the correlation between independent estimates of fat-free weight was 0.988. Actual differences in the estimated weight of fat ranged from -1 to $+3$ kg. Thus, while it is possible that the fat-free weight did change between examinations in some of the cases (as suggested by

the sign test) the apparent changes in the fat-free weight may be used as a measure of the experimental error. Interestingly, the magnitude of the experimental error, thus estimated under rather rigorous conditions, approximates the extent of error reported in replicate studies of the blood-dilution method, as described by Edelman *et al.* ('52).

What is notable here is that the findings agree well with other published studies on fat weight, the weight of the fat-free mass, and sex differences in percentage fat in American men and women of approximately "standard" height and weight.

DISCUSSION

It is evident from these findings that roentgenogrammetrically determined estimates of body composition in adults yield results that are both reasonable and agree well with many values for the weight of fat and the fat-free weight obtained by the densitometric and blood-dilution techniques.

The data for the men are of particular interest because of the number of male series available for comparison, and the good agreement that exists among them. At 176 cm and 76 kg the estimated *mean* weight of fat for the Ohio men was 13.4 kg; this is virtually the same as the mean of 13.7 kg given by Behnke ('53, p. 1095) for men of equivalent size and weight. It is, however, slightly above the estimate given by Edelman *et al.* ('52) for somewhat lighter men, and lower than Brožek's estimate for older Minnesota men of "standard weight" (Brožek, '52). Similarly the estimated mean weight of fat for the student group, 11 kg, agrees within 1 kg with Behnke's value for men of comparable weight, and while 4 kg higher than the value given by Brožek for 48 university students of comparable age (but lower weight), the net difference is not over 1 kg when weight is taken into account.

The female fat data are somewhat more difficult to compare, because published values fall both above and below our mean of 16.0 kg for Ohio women. Edelman *et al.* ('52) give a mean of 17.0 kg for females somewhat lighter than ours. Behnke, on the other hand, provides an estimate of 11.5 kg for women almost identical to ours in the stature and weight. Here, the rather large discrepancies may be due to true differences between the samples, a point emphasizd by many authors, differences between the techniques, or finally, differences in skewness. In our material the mean is approximately 3 kg above the median.

However, it should be noted that the female means given by Behnke are merely *approximations* based on Edward's skin-fold data and male/female ratios in guinea pigs, and not values based on actual determinations (*cf.* Garn, '57c).

In respect to the fat-free weights, the degree of agreement among the male series is exceedingly good, due perhaps to the fact that the fat-free weight is less influenced by nutritional status. The mean estimate for the Ohio men is 62.4 kg: Behnke assumes a mean of 62.7 kg for all age categories. The means of Brožek and Keys ('51) and of Miller and Blyth ('54) are within 1 kg of our estimate, while the mean fat-free weight obtained by subtraction from the data of Edelman *et al.* ('52) is 59 kg. The student group, at 61.5 kg also agrees well with data for men of comparable age. Here, however, the element of sampling stressed by Behnke, Edelman *et al.*, Osserman *et al.* ('50) and others is quite apparent. The farmers and farm-raised subjects in our Ohio series have a notably larger fat-free weight, 68.5 kg, quite like the mean of 68.9 kg reported by Miller and Blyth ('53) for physical education students. The more sedentary professional and clerical workers in our series approximate Brožek's mean for older males of "standard" weight. Obviously, more information than just height and weight should be given in the future when adding data on body composition to the literature.

The fat-free weights for the Ohio women encounter the same difficulty previously noted. Our mean of 44.6 kg is will below Behnke's standard of 49.4 kg, but equally above the mean of 40.0 kg obtained by subtraction from the data of Edelman *et al.* ('52). Further discussion at this time would be pointless, since the source of the inter-group differences is not known.

Interestingly, the women and the men are not too unlike in the weight of fat. Taking the median weight of fat for comparison as is preferred with such skewed distributions, women carry approximately as much fat as men. However, women are relatively considerably fatter (*cf.* Garn, '57b). Computed as per cent of total weight, percentage fat in the female is approximately 50% above the comparable value for the male, a female/male ratio exists in guinea pigs and possibly other mammals as well. But this particular method of computation, though the usual one, is open to objection. Fat may well be computed in relation to the fat-free weight and not as a percentage of gross weight

since the common method of dividing the weight of fat by the gross weight, introduces the same value (fat weight) into both numerator and denominator. At low values of fat this procedure has little effect, but at fat values up to and exceeding the fat-free weight, it tends to conceal the true relationship. By way of example, an individual weighing 100 kg, with 50 kg of fat would have a percentage fat value of 50% by the ordinary calculation, but 100% if expressed in relation to the fat-free weight. Now if fat and fat-free weight were correlated variables, the former method might still be preferred: some value such as 14% for men and 20% for women might be the "norm" at all weight levels. But since fat and fat-free weight are uncorrelated in all adult series we have investigated to date, using the *fat-free weight* as the reference standard instead of gross weight, would appear to be preferable.

The present study emphasizes one problem, only partly explored in the reproducibility tests. How constant may we consider the fat-free weight to be? Here, we have asumed that it is relatively constant, within the span of a few years, and have used our experimental evidence as supporting the validity of the roentgenogrammetric method of determining body composition. However, just as there is some evidence for a decrease in the fat-free weight between ages 20 and 60 (which may be due to secular changes and not a true decrease at all), there is evidence that a gain or loss in fat involves supporting and vascular tissue. In this latter case, fat-free weight may be expected to be constant only within set limits, probably not larger than the experimental error of this or other techniques.

Further, it should be noted that all three techniques for the estimation of body composition involve the same assumption, that of constancy of density and/or composition of the tissues involved. Apart from experimental errors, including the determination of residual air, a major source of error in the densitometric method lies in the assumption that fat has the same density in all people, and at all ages. In the dilution method, the assumption of constancy in the water content of the fat-free mass constitutes a probable stumbling block, even with due correction for age. And in the x-ray method employed here, the assumption that a given thickness of fat may be equated with a given weight of fat remains to be tested. For clinical purposes, these qualifications may be ignored. A person with a low specific gravity, a low

percentage of water, or thick pelvic fat is undeniably fat. But from a research standpoint, the constancy of the "constants" remains an open question; there is much work still to be done.

The roentgenogrammetric technique, like the dilution technique, is subtractive, in that it estimates the weight of one body compartment, and then approximates the remainder by subtraction. This, unfortunately leaves but one degree of freedom, and any error is repeated twice. As Siri has recently pointed out (Siri, '56), there is need for methods that can yield information on fat, on muscle—and other protein—and mineral too. One particular advantage of the roentgenogrammetric technique is that it can be extended beyond its present limits to yield independent estimates of fat, muscle, and bone.

The technique of estimating fat weight, from suitable x-rays has been mentioned before, and is described in considerable detail here. The roentgenogrammetric method also can be adapted to yield excellent approximations to the thigh muscle mass (*cf.* Garn and Gorman, '56), which should correlate well with total functional muscle, except in muscular dystrophies or motor nerve paralyses. And x-rays of the long bones are not only practical but with the work of Trotter already completed (Trotter, '56) they should provide information on a third body compartment, bone, or more specifically mineralized tissue. At the present time we are exploring the use of x-rays of the thigh section to provide the necessary data on a single 14×17 inch film, and without undue exposure to penetrating radiation.

SUMMARY

1. The weight of fat and the fat-free weight were estimated on an individual basis for each of 251 adult males and females, using the thickness of iliac crest fat for females and trochanteric fat for males.

2. Estimated fat-free weights both for a group of Ohio men (mean age 40) and a group of college-age males (mean age 21.7) averaged close to 62 kg, a value in agreement with data obtained by densitometry and blood-dilution on comparable groups. The female mean (44.6 kg) fell between the only two standards presently available.

3. The estimated weight-of-fat distributions were all highly skewed, indicating that the median was the appropriate measure of central tendency. However, using the means for comparison with published

data, both the Ohio men (mean weight of fat 13.4 kg), and the college males (mean 11.0 kg) were in close agreement with comparable series.

4. In the Ohio group the sex difference in the median weight of fat was small (0.8 kg). Percentagewise, however, the women were fatter, approximately 50% above the male. Expressing fat as a percentage of the fat-free weight not only differentiated the sexes better, but distinguished the few highly obese individuals whose weight of fat actually exceeded their fat-free weight!

5. The range of fat weights was 2.0 to 36.0 kg, thus the ratio of the most obese female to the leanest was 18:1. However, comparing the highest to lowest of the fat-free weight, the ratio was far smaller, being 2.0 in the females and 1.6–1.7 in the males.

6. Sorting the data in terms of stature groupings, a rise of 0.6 to 0.7 kg of fat-free weight per cm of stature was obtained. This may be taken as evidence that the effect of stature is not minimized by the present method although stature does not enter directly into the calculations.

7. Replicability studies were conducted on 10 individuals who had gained or lost up to 12 kg in weight. "Before" and "after" estimates of fat-free weight agreed closely with a maximum difference (in one subject) of 3 kg and a mean difference of less than 1 kg.

8. While emphasizing the fact that roentgenogrammetric determinations of body composition yielded results both reasonable and in agreement with other studies, the possibility of obtaining further data on body composition was suggested. In particular, suitable x-rays may provide estimates of muscle mass, and skeletal weight as well.

ACKNOWLEDGMENTS

The author expresses his indebtedness to the following individuals for assistance in the data collection, data analysis and manuscript preparation: Mary Arginteanu, Eloise Barter, Ruth Bean, Lois Conklin, Joan Garlington, Edward Gorman, John Hoins Jr., Lina Landkof and Richard Young.

LITERATURE CITED

BEHNKE, A. R. 1953 The relation of lean body weight to metabolism and some consequent systematizations. Ann. N. Y. Acad. Sci., *56*: 1095-1142.

BROŽEK, J. 1952 Changes of body composition in man during maturity and their nutritional implications. Fed. Proc., *2*: 784-793.

BROŽEK, J. AND A. KEYS 1951 The evaluation of leanness-fatness in man: norms and interrelationships. Brit. J. Nutrition, *5*: 194-206.

DANIELS, S. D., H. C. MEYERS, JR. AND S. H. WORRALL 1953 Anthropometry of WAF basic trainees. WADC Technical Report 53-12 Wright Air Development Center, Ohio.

EDELMAN, I. S., H. B. HALEY, P. R. SCHLOERB, D. B. SHELDON, B. J. FRIIS-HANSEN, G. STOLL, F. D. MOORE 1952 Further observations on total body water. Surg. Gyn. Obst., *95*: 1-12.

GARN, S. M. 1954 Fat patterning and fat intercorrelations in the adult male. Human Biol., *26*: 59-69.

——— 1957a Selection of body sites for fat measurement. Science, *125*: 550-551.

——— 1957b An improved method of estimating body fat content by use of teleoroentgenograms. Fourth Quarterly Report Contract AF18(600)1566, Fels Research Institute, Yellow Springs, Ohio.

——— 1957c Fat weight and fat placement in the female. Science, *125*: 1091.

GARN, S. M. AND J. BROŽEK 1956 Fat changes during weight loss. Science, *124*: 682.

GARN, S. M. AND L. C. CLARK, JR. 1955 Creatinine-weight coefficient as a measurement of obesity. J. Applied Physiol., *8*: 135-138.

GARN, S. M., G. R. GREANEY AND R. W. YOUNG 1956 Fat thickness and growth progress during infancy. Human Biol., *28*: 232-250.

GARN, S. M. AND E. L. GORMAN 1956 Experimental validation of roentgenogrammetrically-determined volumes. Am. J. Phys. Anthrop., n. s. *14*: 374 (Abst.).

GARN, S. M. AND R. V. HARPER 1955 Fat accumulation and weight gain in the adult male. Human Biol., *27*: 39-49.

GARN, S. M., S. SELBY AND R. W. YOUNG 1954 Scalp thickness and the fat-loss theory of balding. Arch. Dermat. & Sypth., *70*: 601-608.

GAGN, S. M., L. W. SONTAG AND F. SILVERMAN 1957 X-ray protection in studies of growth and development. Am. J. Phys. Anthrop., n. s. *15*. In press. (Abst.).

MILLER, A. T., JR. AND C. S. BLYTH 1952 Estimation of lean body mass from basal oxygen consumption and creatinine excretion. J. Applied Physiol., *5*: 73-78.

NEHER, H. V. 1957 Gamma rays from local radioactive sources. Science, *125*: 1088-1089.

NEWMAN, R. W. 1956 Skinfold measurements in young American males. Human Biol., *28*: 154-164.

OSSERMAN, E. F., G. C. PITTS, W. C. WELHAM AND A. R. BEHNKE 1950 *In vivo* measurement of body fat and body water in a group of normal men. J. Applied Physiol., *2*: 633-639.

PETERS, C. C. AND W. R. VAN VOORHIS 1940 Statistical Procedures and Their Mathematical Bases. McGraw-Hill, New York.

REYNOLDS, E. L. 1951 The distribution of subcutaneous fat in childhood and adolescence. Monographs of the Society for Research in Child Development, *15*: (2) Serial No. 50.

SIRI, W. 1957 Determination of total fat, water, protein and mineral in the human body. National Biophysics Conference, Columbus. (Abst.)

SKERLJ, B., J. BROŽEK AND E. E. HUNT, JR. 1953 Subcutaneous fat and age changes in body build and body form in women. Am. J. Phys. Anthrop., n. s. *11*: 577-600.

STUART, H. C., P. HILL AND C. SHAW 1940 The growth of bone, muscle and overlying tissues as revealed by study of roentgenograms of the leg area. Monographs of the Society for Research in Child Development, *5*: (3), Serial No. 26.

SUAREZ, M. 1953 Crecimiento: Metodos de estudio. Publicaciones de Rivista Española de Pediatria, VIII, Zaragoza.

TANNER, J. M. 1955 Growth at Adolescence. Blackwell Scientific Publications, Oxford.

TROTTER, M. 1956 Variable factors in skeleton weight. Human Biol., *28*: 146-153.

LONGITUDINAL STUDY OF PLASMA FIBRINOGEN IN CHILDREN

BY VIRGINIA E. TREVORROW

Child Research Council
Denver, Colorado

PLASMA protein studies are being made on a group of 88 children who are seen at regular intervals throughout their childhood years. The children have been followed for varying periods of time: the youngest child has been seen from age one month through three years and the oldest, from age 7 through 19 years. Each child lives at home with families which are generally of the upper middle class, and is brought to us for study. At the time blood is taken, each child has a complete physical examination and x-ray studies of chest and sinuses. A history sheet is kept by the parents for the interval between examinations recording illnesses, immunizations, etc. Physical examinations and interval histories have been done on most of the children from birth but in several instances, blood work was not started until a later age. Dietary histories have been taken by a trained nutritionist on 43 of the subjects. Determinations of blood constituents are done at one, two, and three months of age, then at three-month intervals to three years, and at 6-month intervals thereafter. Capillary blood is used in the younger children and venous blood at later ages when the child becomes cooperative and has a readily accessible vein. Several determinations are made on each sample of blood, including plasma proteins as separated by a salting-out technique (Hill and Trevorrow, '41) and Tiselius analysis on the venous sera. There is also a complete hematological study, including sedimentation rate.

In all, 2180 determinations of fibrinogen have been made. Of these, 1663 remain as acceptable analyses made during periods of health after elimination of three groups of values: (1) 409 determinations during

or following a possibly significant illness, (2) 22 which we term "subclinical" illness, and (3) 86 possibly questionable for analytical reasons. The last group was determined by calculating for each individual the relationship between his sedimentation rate and the salted-out plasma proteins according to the method described by Meyers ('53) and discarding each determination outside the limit of two standard deviations. It is of interest that the discrepancy was predominantly in the direction of too high a sedimentation rate (75% of healthy and 90% of ill children) and that in 15 instances where Tiselius analyses were done, 11 showed a high alpha-2 globulin, a fraction which does influence sedimentation (Meyers *et al.*, '53). Since the cause of the discrepancy could not be determined in the majority of values in Group 3, all 86 determinations have been discarded. The 22 values in Group 2 represent instances in which there were no positive findings on examination and no significant illnesses, accidents, or immunizations reported on the interval history, yet the laboratory findings showed both sedimentation rate and plasma fibrinogen and/or globulin to be definitely elevated from the usual level and variation shown by the individual. It is possible that a significant event was not recorded on the history, although many were checked by additional consultation with the child and parent at the time of the determination. It seems more likely that this group represents reaction to infection which was overcome without recognized symptoms. Group 1 was chosen by an independent analysis of the pediatric material. It consists of all children who are found at the time of examination to have some inflammatory process, usually, but not always, associated with purulent discharge, or who had recovered from such a process within not more than one week prior to examination.

Within the group of "healthy" determinations there is no difference in fibrinogen levels between boys and girls. A trend with age is shown in chart 1 which depicts the 25th, 50th and 75th percentiles as smoothed by inspection. The median level at one month is 0.205 gm/100 cc which is followed by a rapid drop to a low of 0.145 gm/100 cc at 6 months and then a rise to 0.190 gm/100 cc at the limit of our age reliability at 17 years. In this analysis, each age group from one month through 12½ years contains from 31 to 58 individuals, with decreasing groups to 12 individuals at 17 years. The lowest absolute value for fibrinogen is 0.04 gm/100 cc and the highest, 0.37 gm/100 cc. Twenty-six determinations are 0.30 or higher, two of which are over 0.35 gm/100 cc.

After the sharp decline in the first half year, there is an increase

in fibrinogen concentration for the group as a whole up to two to three years of age. We then see a relative plateau for the next two or three years, followed by a slow, gradual rise to 17. Whether the plateau is real is open to question, however, it seems to be present at each quartile level. The physiological significance of the age changes is not under-

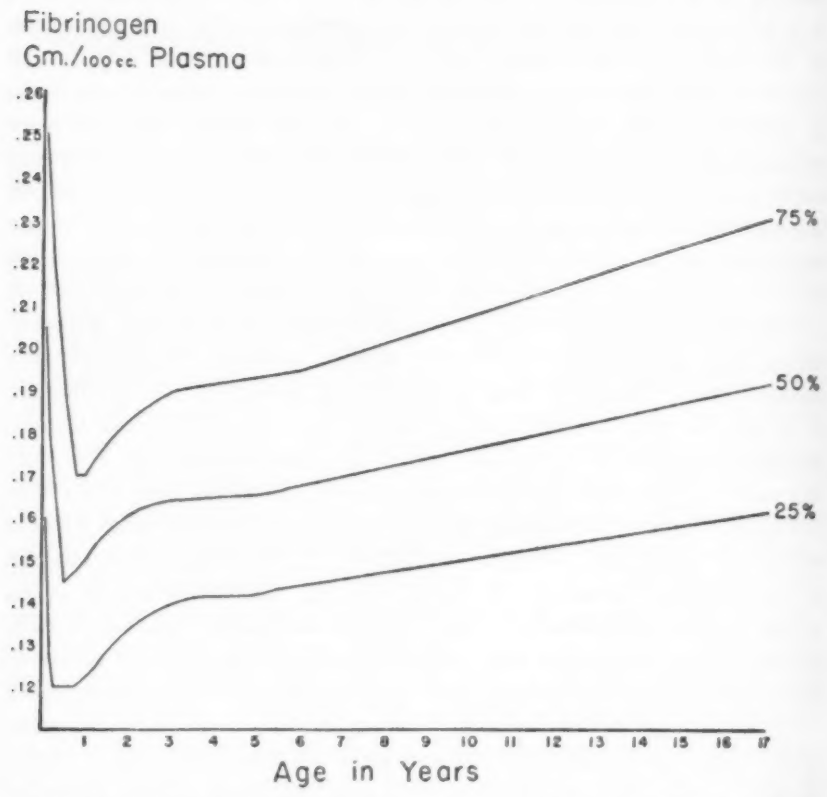


CHART 1. THE PERCENTILE DISTRIBUTION OF PLASMA FIBRINOGEN CONCENTRATION AS IT VARIES WITH AGE.

stood and it should be mentioned that individually the children do not conform to the average pattern, but deviate both in slope and in timing. Nevertheless, since the period of life studied on the 88 subjects has not been identical, and we must therefore compare children seen over different spans of age, each value on each child has been considered in relation to the median trend for the entire group.

For each individual we have calculated the mean and standard deviation of "healthy" values in terms of their deviations from the age median for the group as a whole, with the number of determinations per child varying from 10 to 29. The subjects differ in level from the lowest mean value of 0.059 gm below the age median to the highest of 0.078 gm above the median. They also differ in variability with standard deviation from ± 0.018 to ± 0.067, which difference is not a function of age. The level followed by an individual does not correlate with the variability; that is, children tending to high fibrinogen levels do not vary about their own mean values either more or less than those at low levels.

The question of the significance of the differences between children has been examined from several points of view. With respect to the difference in variability between individuals, Bartlett's test for homogeneity of variance (Snedecor, '46) on either the original observations or the observations expressed as deviations from the age trend line indicates a lack of homogeneity of variance at a level of significance of less than 0.001%.

It was expected that the variability shown by an individual might be related to environmental factors. If this be so, our data do not give conclusive evidence implicating factors of incidence or duration of respiratory illness, or frequency of exposure as it is determined by the number of siblings. There is a tendency for the least variability to be in the first born or only child in the family. These children also tend to have a less than average incidence of infection. Neither of the above relationships is significant at the 5% level. For example, in 8 families we have followed each of the first two children through the period from age 6 months through 4 years. In 6 of the 8, the younger child shows more variability than does the first born of the same family. In this comparison, variability is defined as the error mean square for linear regression of fibrinogen against age as calculated for each child. The probability of this distribution of results is $P = 0.144$, which may indicate a relationship, but is not significant at any usually accepted level.[1]

An exact test for the significance of the differences among means

[1] We have tested approximately the hypothesis that there is no difference in variability between siblings against the one-sided alternative that the variability of the younger sibling exceeds that of the older, by testing, for a binomial with $N = 8$, the hypothesis $p = \frac{1}{2}$ against the alternative $p > \frac{1}{2}$.

for the entire group of 88 children is not possible by any known statistical procedures unless one ignores departures from the assumptions underlying these procedures. These assumptions require that individuals and observations be independent, that the individuals show equal variability, and that the observations on each child approximate a normal distribution. None of these, with the possible exception of the independence of the individual observations, appears to be true for our data. In addition, we have considered values in relation to the age trend in order to remove age, *per se*, as a factor. This technique assumes that each child follows this average pattern, which, as stated above, is not always the case. If we forego statistical analysis and examine the material graphically, we find that one child at the upper end of the distribution has been consistently above the group median over a span of 11½ years, and another child has no "healthy" value above the trend line over a 10½ year period, each child having been followed from infancy to his present age. As further demonstration of the thesis that an individual tends early in life to establish a level of fibrinogen which he maintains during periods of good health and to which he returns following elevations resulting from illness, we have calculated the mean healthy level for each child during his 2nd, 4th, and 11th years and compared these periods. Chart 2 depicts the relationship between the 2nd and 4th years, and chart 3 shows those children who were seen in their 2nd and 11th years. This approach would seem to indicate that a level is established by the second year.

We have next tried to correlate the illness record in the first two years with the childhood fibrinogen level. Severe respiratory illness has been used as the measure of illness since other types of infection have been too uncommon to offer any reliable data. Other miscellaneous diseases, immunizations and allergy will be mentioned later. The presence or absence of siblings has been considered since their presence is believed to increase exposure to infections. One half of the group (43 children) with higher childhood fibrinogen levels have a history during their first two years of 36 acute upper respiratory infections with fever compared with 28 infections in the half with lower fibrinogen levels, several in each group having no infections other than a mild runny nose during the two year period. For those children having older siblings, 27 with high fibrinogens show 23 infections and 22 children in the low group suffered 19 infections. A similar study was made of the health history during the first six years of life for all children who

have reached this age. The results are summarized in table 1. Here again the frequency of infection does not vary with the fibrinogen level. Thus, the frequency of infection does not appear to be a determining factor in setting the fibrinogen level, and conversely, the fibrinogen

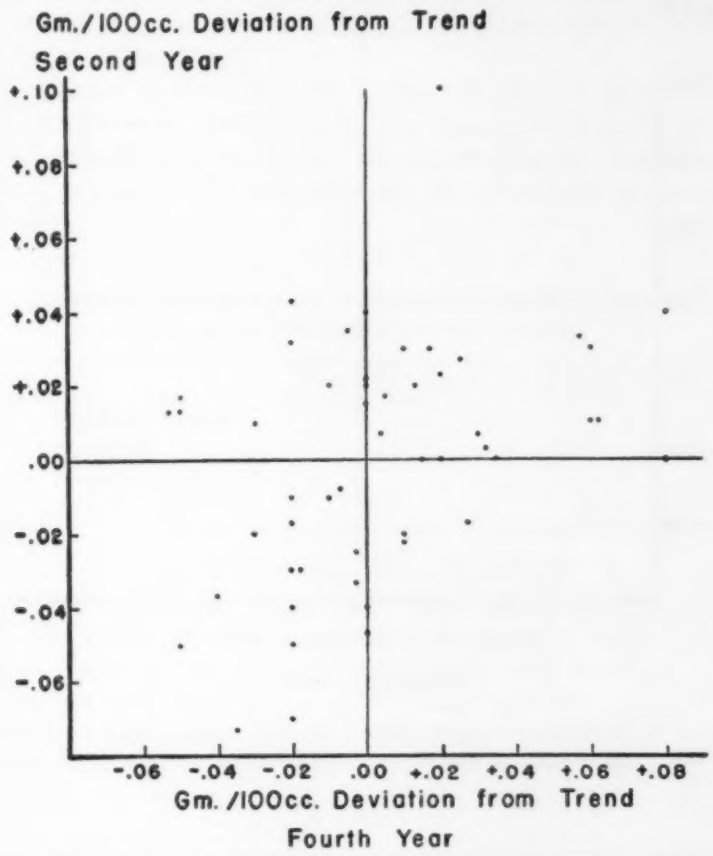


CHART 2. FIBRINOGEN CONCENTRATION IN THE SECOND YEAR OF LIFE COMPARED WITH THE VALUE ON THE SAME INDIVIDUAL IN THE FOURTH YEAR.

level at the time of exposure to disease does not alter the frequency of infection. Similarly there is no correlation between the mean duration of respiratory infection and the healthy level of fibrinogen, as shown in table 2. It is apparent that the pre-exposure level of fibrinogen bears no relation to the course of the disease. With respect to

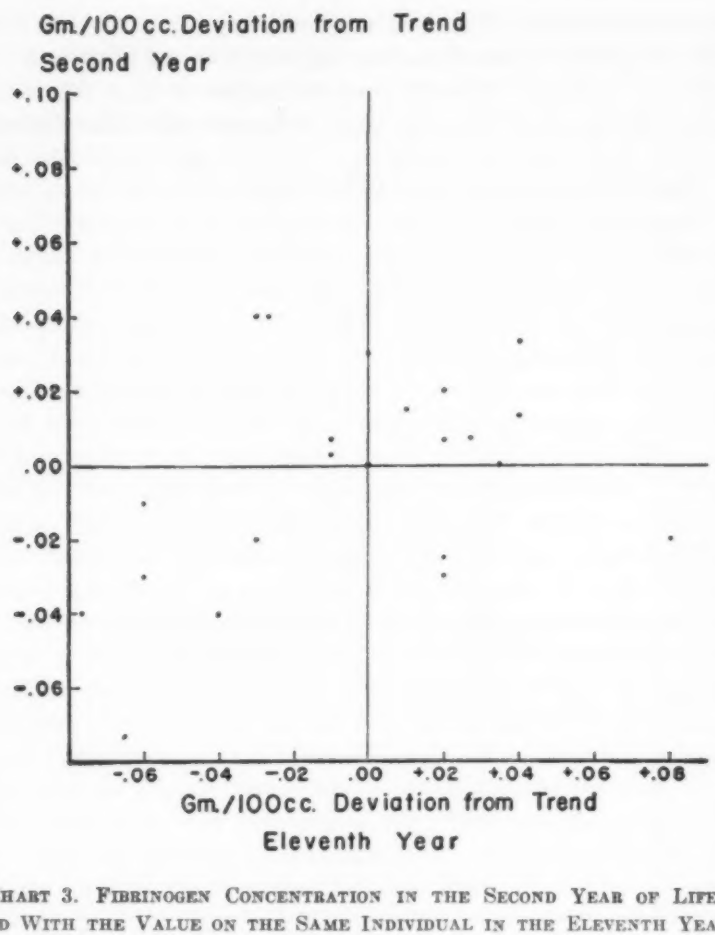


CHART 3. FIBRINOGEN CONCENTRATION IN THE SECOND YEAR OF LIFE COMPARED WITH THE VALUE ON THE SAME INDIVIDUAL IN THE ELEVENTH YEAR.

TABLE 1

Number of children showing indicated frequency of severe respiratory illness during the first six years of life.

	HIGH FIBRINOGEN		LOW FIBRINOGEN	
	1st born	Older sibling(s) in family	1st born	Older sibling(s) in family
Three or more illnesses	7	14	10	13
Less than three illnesses	8	7	10	7

childhood diseases and infections other than respiratory, the high and low fibrinogen groups are equally divided with 29 of 44 children in each group free from these infections. Definite allergy was present in 28 of those with high fibrinogens and in 26 of the low group. Our subjects offer no opportunity to study the effect of immunization, since only three children are known to have received no immunization during the first two years.

In addition to the differences between children in level and variability of fibrinogen during health, there also seems to be a difference in their responsiveness to illness. On 17 occasions an infant was seen within 7 days of D. P. T. immunization. In 12 of these, the fibrinogen

TABLE 2

Number of children showing indicated mean duration of severe respiratory illness during period of study.

	HIGH FIBRINOGEN	LOW FIBRINOGEN
Duration average or above	17	19
Duration less than average	23	20

was at or above the level of plus three standard deviations from the child's healthy mean value; in three, the level was plus two standard deviations, and in the other two, there was no significant fibrinogen increase. Among older children, one boy was seen between 6 and 19 years of age with pink eye on one occasion and twice within 7 days of an upper respiratory infection with fever. In all three instances his fibrinogen rose to above the plus three standard deviation level. In contrast, another child between the ages of three and 8 years had pink eye with no response and was seen on 4 occasions within 7 days of an upper respiratory infection with fever, showing no response in three of the 4 illnesses. If one considers this apparent difference in responsiveness in relation to the health history, one again finds no correlation. For example, 10 children who have always shown an elevated fibrinogen following infection are compared with a group of 14 who have not shown such an elevation and who have each been seen on at least two occasions when such a response was expected. In the responsive group, 60% have average or less than average incidence of

respiratory infections while in the non-responders, this is 58½%. The responding group have a mean duration of illness of —0.03 days from the average for all children whereas the non-reacting group average —1.16 days but deletion of one child with 11 short, treated illnesses changes this mean value to +1.00 day.

The 43 children on whom there is an adequate dietary study show

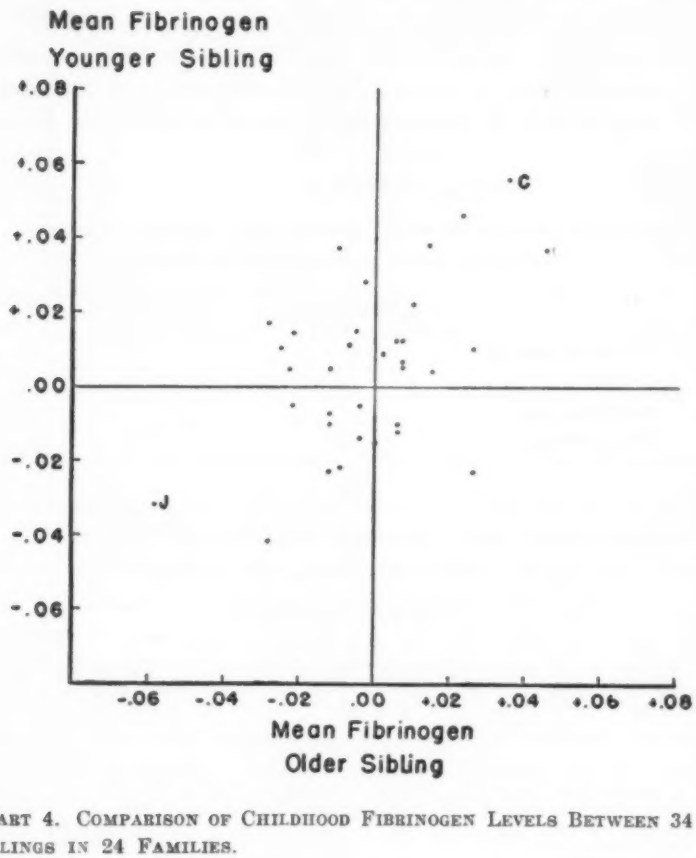


CHART 4. COMPARISON OF CHILDHOOD FIBRINOGEN LEVELS BETWEEN 34 PAIRS OF SIBLINGS IN 24 FAMILIES.

no correlation between fibrinogen level and protein intake. Chart 4 shows the relationship between siblings in their fibrinogen levels. It is of interest that the pair marked "J," with low fibrinogens both have a higher protein intake than the pair marked "C" who are both at the upper end of the fibrinogen distribution in spite of a relatively low

protein intake as compared with standards based on a study which includes these 43 subjects (Beal, '53). This inverse relationship does not hold for the group as a whole. Ham and Curtis ('38) have shown that extremes of protein intake can influence fibrinogen levels in a positive direction, however, it should be pointed out that our subjects all receive a diet which is considered to be adequate: none is clinically deficient, and probably none has ingested protein in amounts as high as the supplemented diet used by Ham and Curtis.

We believe that individuals do differ in their level and variability of fibrinogen during health and probably in their fibrinogen response to illness. Insofar as these differences have not been accounted for by environmental factors, as expressed in the health and diet histories, it would appear that the explanation may lie in a difference in physiology, possibly genetically controlled. Within our series of children there are 24 sets of siblings, two or three in each family. Such a group is not subject to any statistical proof of genetic determination; however, that such a possibility exists is demonstrated in chart 4. This chart graphs the older sibling against the younger child for 19 families with two children and 5 families with three children, giving a total of 34 pairs. The probability that such a distribution should result from chance alone is about 0.05 by either the chi square test or the corner test of association (Mood, '50). It would appear that families, in some instances, do tend to show an intra-family similarity in the fibrinogen level of the children, and do show real differences between families. If families are different, then our view that individuals within the whole population show real differences, is further substantiated. As with individuals, the families who are distinctly high (upper three families) do not show a consistent difference in health pattern from those families who are distinctly low (lower two families). Within these families which tend to show sibling similarity at the extreme levels, the health histories within any given pair of siblings are often quite different. For example, one family with low levels shows the older boy with 5 significant illnesses in 13 years, with an average duration 4 days longer than that for the group as a whole; the younger boy has had 8 significant illnesses in only 10 years, but each has been of shorter than average duration. Both boys are allergic. In a family with high levels, the older girl has had 8 illnesses in 7 years, with a mean duration one day shorter than average, while her younger brother had only one illness in 5 years but that was of long duration. Only the younger child is allergic. The

intra-family relationship does not result from similarity of known environmental factors, and may therefore be of genetic determination.

The genetic control of fibrinogen synthesis has been discussed by many workers in relation to those cases where the level is low enough to interfere with normal clotting. A bibliography to this work is presented by Graham ('56). The present longitudinal study of fibrinogen might indicate that genetic control exists within the "normal" range of values as well as in the abnormal case of afibrinogenemia.

SUMMARY

Plasma fibrinogen has been determined in a group of 88 children who were followed longitudinally over a period of several years. Physical examinations including x-rays have been done on each child from birth, complete health histories are available on 86, and records of dietary intake on 43 of the subjects. Complete hematological examination including sedimentation rate was done on each blood sample. One thousand six hundred and sixty-three fibrinogen analyses were done on the children during periods of health with the number per child varying from 10 to 29.

The level of fibrinogen changes with age. These changes are described for ages from one month to 17 years.

Individuals differ from each other in their level of fibrinogen, in their variability, and possibly in their fibrinogen response to infection. These differences show no correlation with frequency or duration of infections, sibling position in the family, or protein intake.

The level of fibrinogen does tend to be similar within the children of some families. Insofar as known environmental factors have not correlated with the fibrinogen level, it may possibly be genetically controlled.

ACKNOWLEDGMENT

The author, who contributed the plasma protein studies, thanks other members of the staff of the Child Research Council for making available and analyzing their data in the fields of pediatrics, hematology, x-ray, nutrition, and biometry.

LITERATURE CITED

BEAL, VIRGINIA A. 1953 Nutritional intake of children. J. Nutr., *50*: 223-234.

GRAHAM, JOHN B. 1956 Biochemical genetics of blood coagulation. Amer. J. Human Genetics, *8*: 63-79.

HAM, THOMAS H. AND F. C. CURTIS 1938 Plasma fibrinogen response in man. Medicine, *17*: 413-445.

HILL, ROBERT M. AND V. TREVORROW 1941 Plasma albumin, globulin, and fibrinogen from birth to adult life. J. Lab. and Clin. Med., *26*: 1838-1849.

MEYERS, ALDULA J., V. TREVORROW, A. H. WASHBURN AND E. R. MUGRAGE 1953 Quantitative studies of the influence of plasma proteins and hematocrit on the erythrocyte sedimentation rate. Blood, *8*: 893-904.

MOOD, ALEXANDER MCFARLANE 1950 Introduction to Theory of Statistics. McGraw-Hill, New York.

SNEDECOR, GEORGE W. 1946 Statistical Methods, Ed. IV. Iowa State College Press, Ames, Iowa.

BOOK REVIEWS

A Symposium on the Chemical Basis of Heredity. Sponsored by the McCollum-Pratt Institute of the Johns Hopkins University with support from the Atomic Energy Commission. Edited by W. D. McElroy and Bentley Glass. The Johns Hopkins Press, Baltimore, 1957. xiv + 848 pp. $12.50.

This volume consists of papers and discussions presented at a symposium held at the Johns Hopkins University June 19-22, 1956. Those who attended this or any of the previous symposia, or read the 6 volumes of the proceedings, will not need to be told how valuable and stimulating is the product. Those unfamiliar with the series should be informed that this is an important book.

The book is divided into 8 sections. The titles of the first 7 sections are: Cellular Units of Heredity; Role of the Nucleus; Nucleic Acids and Associated Substances in Cell Division and Protein Synthesis; Nucleic Acids as Transforming Agents; Viruses as Bearers of Heritable Characteristics; Nucleic Acids—Chemical Composition and Structure; Synthesis of Nucleotides and Nucleic Acids; and Mechanism of Duplication. A section generally contains about 6 papers, plus one or more discussions, although the seventh consists of but two papers. The eighth and last section is a summary by Bentley Glass (77 pages).

The authors and editors have given us a very useful and dynamic presentation of our present knowledge of the chemical nature of the basic genetic material, the way nucleic acids may control their own autoduplication and the synthesis of proteins, and much else besides. Merely from the list of topics covered it is apparent that the result is a valuable summary of contemporary work in several related fields which together constitute a subject in which, one cannot help but believe, a decisive break-through is to be expected in the near future. As a basis for the understanding of this advance, this volume may well be indispensable. In the meantime no scientist interested in the problem of the chemical basis of heredity will want to be without the book. It should be said, however, that this is not an ideal introduction to the subject for the beginner, since the authors, being authorities in their respective fields, and speaking primarily for the benefit of their colleagues, devote little time to elementary introductory matters and generally plunge im-

mediately into a presentation of their own contributions and ideas. A diligent study of the summary might help somewhat to remedy this relatively minor drawback, but on the whole the non-specialist should take up the Symposium realizing that he may find parts of it hard going.

Fifty-six authors were responsible for the papers presented, and this seems too long a list of names to give here: they are all outstanding workers in the fields represented, mostly Americans, naturally, but including some distinguished investigators from abroad. It would be invidious, and not a little difficult, to single out any particular paper or papers as the best or most important. The interested reader will want to read them all.

There is an author index, a subject index, and a list of additional participants.

WILLIAM C. BOYD

Boston University,
School of Medicine,
Boston, Massachusetts

Immunology and Serology. By PHILIP L. CARPENTER. viii + 351 pp. W. B. Saunders, Philadelphia and London, 1956. $6.50.

Blood Group Substances: Their Chemistry and Immunochemistry. By ELVIN A. KABAT. ix + 330 pp. Academic Press, Inc. New York, 1956. Price $8.00.

These two books are almost exactly the same size, they were published at about the same time, and they deal with closely related subjects; yet in treatment they differ almost as widely as two serious scientific books can. Dr. Carpenter writes as a teacher; he leads us painstakingly through the vast field of immunological knowledge over carefully graded highways, but it is only from a distance that we are allowed to see, dimly, the borderland of existing knowledge. Dr. Kabat, on the other hand, as a pioneer investigator, leads us very rapidly over the long-established facts, straight to the incompletely surfaced roads which border the frontier.

Dr. Carpenter's book is carefully written; unlike the authors of so many modern text books he has thoroughly assimilated and co-ordinated the facts himself before setting them down. In so far as I can judge a book that deals mainly with matters outside my own specialty, I think I can recommend it as a sound introduction to immunology and serology.

A glance at the references, however, shows that few of them are dated later than 1950; and several important recent developments in immunology are mentioned only briefly or are omitted entirely.

On the use of precipitin reactions in the taxonomic classification of animals one would have welcomed some account of the work of Weitz and of the more recent developments in the work of Boyden. The description of the serological classification of plants is most welcome, as it is not generally known, but some mention should have been made of the presence of specific hemagglutinins in the seeds of many plants.

In the description of the human blood groups scarcely any mention is made of the vast amount of work done in the past 10 years: characteristically, the one specific recent discovery mentioned is the introduction of a technique, that of enzyme treatment of red cells to promote agglutination. The account of the anthropological application of blood grouping is completely out of date.

No mention is made of the existence of specific blood group hemolysins in the serum of various species of mammals including man; we are not told that most cattle blood grouping tests are carried out by a lytic technique, nor of the first discovery of iso-immunisation by Ehrlich and Morgenroth in goats which involved the production of such lysins, and was made within a few months of the discovery of the human blood groups by Landsteiner.

The most serious omission of all, however, is that of any mention of acquired immune tolerance. The development of the subject is admittedly recent, but blood group chimeras have been known in cattle since 1945 and in man since 1953. The literature of acquired tolerance to tissue grafts is already extensive and is leading, in the hands of such workers as Burnet and Medawar, to a fundamental transformation and enrichment of the whole theoretical background of immunology. The former of these has introduced the idea that the organism recognizes certain immunological markers which tell it whether a substance is 'self' or 'not self'; it tends to make antibodies to the latter. If, however, a foreign substance is introduced to the organism at a sufficiently early stage of the latter's development, it becomes accepted permanently as part of the 'self.' This suggests that the ability to distinguish the 'self' is actively acquired and not passively inherited.

No misprints have been noted in the text. Among a dozen references checked, one numerical error was found, and the author and printer have failed before the shibboleth of the name 'Ingebrigtsen.' This is

the fourth work in which I have come across references to this author, and in every case his name has been misspelled.

Blood Group Substances is a much harder book to read but much more rewarding to those who make the effort. Dealing with a narrower field, it does so in a very thorough manner; the literature up to the beginning of 1955 is covered with admirable completeness, but the book is no mere catalogue of publications—every fact is clearly and concisely related to the whole field. There are over 1,200 references; those checked proved correct.

The first chapter is a higly concentrated but remarkably complete account of present-day knowledge of the blood groups, especially those of man. The second describes standard techniques used in blood grouping, as well as some of the methods used in investigating the structure of the blood group substances. The ground of the first chapter and most of the second is already covered by other books but it is useful to have the material brought together here as an introduction to the more specialized part of the book. Subsequent chapters deal with the sources of blood group substances, their purification, their chemical composition and immunochemical characterization, and differences between substances derived from different animal species. A long chapter describes changes produced by various reagents, and the attempts which have been made to determine the precise structure of the substances. Another describes the blood group antibodies, their reactions with the antigens, and their biological effects, and the last deals in a broad way with the biological significance of the blood group substances. This last chapter is of greater general interest to biologists than the others but can scarcely be understood without some knowledge of what has gone before.

The blood group substances clearly play a much more important part in the scheme of living things than is implied by their name. Considering only the substances of the ABO system, in man they are present in a variety of tissues and, in most people, are poured out in vast quantities in the mucous secretions. Similar substances are found in the red cells, tissues and secretions of many, possibly all, vertebrates, while closely related substances are present in certain plants, and in the capsules of bacteria. Antibodies which react specifically with the blood group substances occur not only in human and other mammalian sera but also in extracts from the seeds of a variety of plants, mostly leguminous.

Our knowledge of the composition and structure of the blood group

substances is mainly due to the work carried out in the laboratory of the author, and in that of Professor W. T. J. Morgan in London. The residues, consisting of monosaccharides and amino-acids which go to make up the complex molecules, are now almost completely known and a beginning has been made in elucidating their arrangement, especially in that part of the molecule which determines their specific serological properties.

We do not know the function of these remarkable substances, though the differential incidence of certain diseases in relation to the blood groups must be an important clue. The author mentions a similarity between the blood group substances, and the intrinsic factor which is deficient in the gastric secretion of cases of pernicous anemia: since the book went to press a statistical excess of group A individuals has been found among sufferers from this disease. Several other substances of physiological importance, such as chorionic gonadotrophin, show chemical and immunological resemblances to the blood group substances, the study of which may help to reveal the function of the latter.

Another outstanding problem is that of the mechanism whereby the blood group genes determine the complex chemical structures of the corresponding substances, but there are indications that the H substance, found mainly in the secretions of O persons, is a basic molecule upon which the A or the B " stamp " may be impressed by the corresponding gene.

To all those who are interested in serology and possess a basic knowledge of organic chemistry this book can be strongly recommended.

A. E. MOURANT

Blood Group Reference Laboratory,
The Lister Institute,
London, England

Human Ovulation and Fertility. By EDMOND J. FARRIS Philadelphia: J. B. Lippincott Company, 1956. $6.50.

In this book, Dr. Farris expresses the commendable hope that by and from it the infertile couple will be helped to attain the joy of family fulfillment.

Because " normalcy," evidenced by the absence of obvious faults as revealed by the histories and examinations of both the man and woman,

does not of itself assure the success of a mating, and because the human species does not exhibit oestrus as one recognizes it in many other mammals, the author stresses the proper timing of coitus as a matter of primal importance. He briefly alludes to the several conventional criteria of ovulation and then goes into considerable detail over the rat-ovary hyperemia test with which he has had rather singular success in establishing the fact and time of ovulation in women.

Excellent correlations are described between the hyperemia test and the appearance of the ovaries, notably the follicles and corpus luteum, and of the endometrium as revealed at operation. Interesting to note was the measured increased amount of voluntary muscular activity at the time of ovulation, a phenomenon commonly observed in domestic animals at the time of oestrus. The hyperemia test is dependent on the close adherence to essential precautions. Rats of a specified strain are required. Positive or negative results are based on color changes induced in the ovaries in response to the injection of urine at different phases of the menstrual cycle. The rats must be killed with illuminating gas of a special composition, and the ovaries must be inspected under special lighting conditions. Resultant degrees of redness are compared with those of the Munsell color chart. That the test can be read within two hours after the injection is an obvious point in favor of this method.

In the author's experience the high incidence of conceptions resulting from isolated coitus based on proper timing, which in turn was based on the hyperemia test, would bespeak of the advantage of the method. According to the data, 92% of the conceptions occured between days 10 and 16 of the menstrual cycle. When artificial inseminations were employed on the alleged days of ovulation, based on the hyperemia test, 35% of the 100 conceptions followed single inseminations—a truly remarkable achievement. Many clinicians would, however, be opposed to the author's method of injecting the semen into the uterine cavity. Still more extraordinary is the assertion that 96.5% of the women become pregnant by the 3rd homologous insemination, and 73% by the heterologous procedure. It would be of interest if other workers could accomplish so successful a feat. Dr. Farris states that the average length of menstrual cycles is so constant that only three consecutive cycles are necessary from a practical standpoint to establish a pattern. This conclusion is inharmonious with the incidence of failure, *i. e.*, the large number of unwanted pregnancies which result from the employment of the "rhythm" or the so-called "safe period"—evidence of variations

in the cyclic patterns which the experienced obstetrician will attest. This being so, one questions the practical advantage of employing the hyperemia test when simpler methods for timing ovulations are available.

While one admits that the functional life span of the unfertilized egg is brief, this fact hardly warrants the recommendation that coitus should occur at a specified hour by day or night to be successful, save in the woman of greatly diminished fertility. Elsewhere the author offers practical hints for improving the pattern of ovulation. The familiar advice of adjusting the basal metabolic rate is again given. However, the great benefits claimed of pituitary irradiation has just as ardent opponents.

All in all, this book offers some practical advice helpful for the couple which desires to achieve a pregnancy. The reviewer feels that the author has had truly unusually good fortune in the treatment of infertile couples, but feels that some of his several formulae are oversimplifications of the very complicated problems of fertility. Important as is the timing of ovulation, the realms of endocrinology and other environmental factors of the reproductive tracts of men and women do not receive the attention they warrant, but perhaps Dr. Farris's main objective was to emphasize the merits of his hyperemia test.

W. T. POMERENKE

University of Rochester,
Rochester, New York

Life Tables From Limited Data. By GEORGE J. STOLNITZ. 164 pp. Office of Population Research, Princeton University. 1956. $4.00.

This book contains an exposition of the methodology which the author has developed for constructing life tables when primary reliance has to be placed on information obtained in a single census. Conventionally, life tables are based on age-specific rates derived from population and mortality data by age. There are circumstances, however, when data on deaths by age are not available or are of doubtful validity and substitutes for them can not be derived from successive censuses. The single census methodology probably has greatest application in underdeveloped areas having only scattered censuses. In addition, several potential applications of life tables based on the single-census approach are listed in the final chapter of the book.

After briefly discussing the plan of the book in Chapter 1, the author presents in Chapter 2 the general analytical scheme for constructing life tables from a single census. Of foremost importance to this scheme is the development of formulas for computing age-specific survival rates. These formulas require a knowledge of the comparative experience of successive pairs of age groups. It is significant that they depend on ratios rather than frequencies since the former are much easier to estimate than the latter. Even so, estimates of birth survival and population ratios for successive pairs of age groups would rarely be available directly for areas utilizing the single-census approach to compute life tables. The discussion in Chapter 3 relates to problems of estimating birth and survival ratios by indirect means involving the use of substitute data provided by other areas having similar demographic characteristics. The discussion in Chapter 4 relates to methods of adjusting the population ratios so that they correspond to the birth ratios and are free from the effects of past migration.

It is basic to the author's approach that sufficient safeguards exist to insure the rejection of life tables when the single-census approach produces intolerable errors. In Chapter 5, he presents some guides for detecting major inaccuracies in the age-specific rates from a knowledge of the typical variations in these rates between the sexes and by age. The results of an empirical test of the single-census approach are discussed in Chapter 6. Forty-seven life tables were prepared for populations representing a variety of statistical and demographic circumstances for which conventionally computed life tables are available. The author concludes that most of the estimates of survival rates erred by less than 2% at ages under 50 years and that beyond age 50, the probable range of errors tends to increase with rising age to about 5 and 10% at ages between 60 and 70. Estimates of the average duration of life between 2.5 and 67.5 years in these experiments fall within 5 to 6% of the correct values and all but a small minority fall within 10%.

Two new life tables for the American native-white population about 1890 and the native population of Brazil about 1940 are presented in Chapter 7. The chapter contains a detailed exposition of the adaptation of the single census approach to these two populations lacking adequate mortality data and presenting very different problems in estimating birth, survival and population ratios needed in order to compute age-specific survival rates.

In summary, the author has formulated an approach for constructing

life tables which should prove useful in many circumstances where mortality data for the population groups under study are missing or are inadequate. He has indicated that this approach which places primary reliance on information found in a single-census frequently produces usable statistics. Moreover, he has provided a system of direct and indirect checks to insure the probable rejection of the life tables results when they are prone to excessive errors. The author has done his job well, and he has provided the potential appliers of this methodology with an excellent reference book.

MONROE G. SIRKEN

Actuarial Analysis and Survey Methods,
National Office of Vital Statistics,
Washington 25, D.C.

Tobacco Smoking Patterns in the United States. By WILLIAM HAENSZEL, MICHAEL B. SHIMKIN, and HERMAN P. MILLER. viii + 111 pp. U. S. Public Health Monograph No. 45. Washington, D. C., 1956. $0.60.

Smoking has a variety of aspects that are of biological and medical interest and significance. The present monograph provides a comprehensive documentation and analysis of smoking patterns in this country. The primary data for this survey were provided by a supplement to the Current Population Survey of the Bureau of the Census for the month of February, 1955. The data were tabulated by current and lifetime smoking patterns. Special attention is paid to "mixed smokers" who regularly use more than one form of tobacco and to those who discontinued smoking. Cross-tabulations are presented with standard census categories including sex, residence, geographic region, race, employment status, marital status, etc.

The procedures for gathering the data were the same as used by the inter-census surveys. As the survey was conducted during day-time, when a large number of men were not at home, self-response rates for men fell as low as 58 percent. The validity of the history data for those not responding for themselves is open to some question; comparisons on some variables indicate fairly consistent underreporting of the occurrence of the smoking practice. The extent to which bias is carried over to estimates of such factors as age-started-smoking and age of maximum use is not indicated. Use of the basic American Cancer

Society questionnaire, with small improvements designed to reduce ambiguity, provided needed continuity with other work that has been done.

The monograph includes a complete appendix with detailed cross-tabulations. An addendum by Milmore and Conover gives a concise picture of the history of the use of tobacco in the United States from 1880 to 1955. Although the primary use of the data may be epidemiological exploration, other uses suggest themselves. The data provide the basis for selection of stratified samples for study of particular smoking patterns. For example, if one wished to study multiple smokers, these data would show in which population groups multiple smokers are most prevalent. It is hoped that social, as well as biological medical scientists, will find this a useful source of documentary information and of further research problems.

DAVID M. SHAW

University of Minnesota,
Minneapolis, Minn.

Toward a Unified Theory of Human Behavior. Edited by ROY R. GRINKER and HELEN MACGILL HUGHES. xv + 375 pp. Basic Books, New York, 1956. $6.50.

As more and more fields of scientific enquiry split off from philosophy after finding each its own way of studying experimentally an aspect of the universe, each in turn goes through a period in which philosophy is regarded with disdain and suspicion. As the time required to learn the techniques peculiar to the young but growing science increases, the time for broader education (which might include philosophy) decreases and the specialization becomes deeper but narrower until finally in many areas technical skills threaten to predominate and contact is lost with the larger issues.

Every now and then better minds revolt against the isolation and fragmentation imposed by this specialization of science and an attempt is made to regain an overall view. Such a revolt can take many forms: an individual scientist can turn philosopher and write about matters, strictly speaking, outside the domain of his special competence. The quality of his mind is usually such that we enjoy reading the products of his leisure-time thought. One thinks of Einstein, Alexis Carrell, Max Born, Fulton and many others. At other times an attempt is made

to build bridges between several disciplines by organizing an interdisciplinary journal such as *Studium Generale* or an interdisciplinary conference or symposium. Occasionally one individual works out a new concept which, for a time, brings several unrelated domains together. Selye's adaptation syndrome, Shannon's information measure, Cannon's homeostasis were such concepts acting in the manner of a searchlight directed toward a famous building: if skillfully placed, it throws new facets of the familiar landmark into thrilling relief.

This reviewer missed that rare quality during the reading of *Toward a Unified Theory of Human Behavior*, an account of the first four conferences of a group of behavioral scientists meeting from time to time to search for common theoretical ground in the behavioral sciences. The text is not a verbatim copy of the presentations and discussions, but rather an extremely well edited condensation.

The individual presentations range from compact summaries of some key concept to attempts to develop a hierarchy or system of concepts. Each speaker seems to have expected on the part of the other participants a great deal of familiarity with the ideas he presented. Not a single paper could stand on its own as an introduction to a theory of behavior or to a field of research, as was done in the 1952 Oxford Conference on Mental Health (*Prospects in Psychiatric Research*, J. M. TANNER, ed., Blackwell, London, 1953) or the early Josiah Macy symposia.

Perhaps the paper by Laura Thompson who sketches how anthropologists are struggling to find a culture concept which will unify them or Florence Kluckhohn's summary of 5 key problems to be solved in any Weltanschauung come closest to giving a completed whole. Roy R. Grinker, John P. Spiegel, and David Shakow each in turn indicate some analogies between psychological and group phenomena while Jurgen Ruesch reviews some concepts of communications theory as does Karl Deutsch.

Talcott Parsons introduces 4 laws from his general theory of actions and mentions the problem of the relation between the small group and the larger social system. Jules Henry develops some suggestive equations to describe relations between reward and punishment and between psychological commitments and fulfillments. James Toman reviews some of the multiple origins of the uniqueness of human society and discusses the complementary roles of stability and adaptation as dynamic reciprocating mechanisms in the service of evolution. Alfred Emerson underlines the fact that homeostasis is compatible with or

may even encourage increase in variability whereas Anatol Rapoport looks at homeostasis from the vantage point of mathematical biophysics and spells out the concept of statistical boundaries.

Lawrence Frank pleads for a place for the culture concept and field concept and, most challenging of all, for the inclusion of the concept of growth and individual development within the unified theory. It was after this paper that the discussion became the most interesting and here probably the idea was first conceived of testing the applicability of concepts obtained from the study of biological heredity to theories about cultural transmission which led later on (after further discussions at the Stanford Center for Advanced Study in the Behavioral Sciences) to an exciting paper by Gerard, Kluckhohn and Rapoport on analogies between "biological and cultural evolution" (Behavioral Science, *1*(1): 6-34, 1956); ideas which also led to a series of experiments at Michigan on changes in problem solving "culture" in small groups with continuous replacements of individuals, imitating on a small scale the gene pool with its relative independence from particular individuals.

Reactions to this volume will vary. Some individuals may not be able to finish reading it, while others will praise it highly. In taking a middle position let us summarize some of the criticisms first.

a. There is at times too much display of the qualities exposed by Sorokin in his vitriolic book "Fads and foibles in modern sociology and related sciences" (Regnery, 1957): lack of modesty, lack of clarity and misuse of concepts from the physical sciences.

b. There is apparent in some discussions a lack of elementary training in philosophy as, for instance, when structure and function are confused or more seriously when the word "system" is *simultaneously* used in at least three distinct meanings: *1.* an interrelationship between constituents of a cell, organ, individual, or society; *2.* a model of such a relationship; *3.* a general theory about such models.

c. Grinker's able summaries after each presentation do not succeed in pulling together what are essentially no more than highly intelligent conversations.

d. There is frequently a display of "cultural" snobbery as when currently fashionable terms such as "transactional" are used without elaboration or clarification.

e. In spite of the careful editing there remains much repetition, partly due to the fact that the reader gets in one volume what those attending the conferences got in 4 widely spaced installments.

Some of the criticisms are patently unjust because they confuse intention and result. It can hardly be expected that a group of individuals meeting only for brief conferences will produce philosophically sophisticated and technically complicated supertheories *ad hoc*. It will take prolonged efforts and much ingenuity and enthusiasm to succeed in such a task. Most of these men are very busy. It may be necessary to create special niches for individuals who have the inclination and show promise of developing the ability to compare and integrate concepts from different disciplines. Certainly philosophy and logic should be part of the training of such individuals. In the meantime interdisciplinary groups such as this one can make a good start in clearing the ground of dead wood and rotten stumps.

The self-criticism, common sense and contagious enthusiasm of this group is evident. A new quarterly journal "Behavioral Science" and a new "Society for the Advancement of General Systems Theory" are continuing the search.

STEVEN G. VANDENBERG

University of Michigan,
Ann Arbor, Mich.

Interpersonal Diagnosis of Personality. By TIMOTHY LEARY. xix + 518 pp. New York: Ronald Press, 1957. $12.00.

In our modern "dynamic" age the simple question, How is personality to be adequately described?, hides a complex web of problems. The need for an evaluation of unconscious motivating forces on the one hand and the potentiality for quantification on the other has been the focus of much discussion. The system of description presented in this book offers a constructive approach to these problems. It is a multi-level system of description, including the levels of concrete behavior, conscious perceptions, and unconscious forces. The data obtained is analyzable qualitatively as well as by standard statistical techniques. Levels are defined separately; the uni-level ratings are then fitted into a pattern which reflects the interplay among the levels.

It should be noted that the Interpersonal Diagnostic System is "diagnostic" because it grew out of a clinical situation. The book, though concerned with interpersonal behavior "primarily as expressed and observed in the psychotherapeutic setting," presents a general system of description designed to be applied to the description of people in any and all settings.

The book is divided into 5 parts. Part I, entitled, "Some Basic Assumptions about Personality Theory," is an interesting, but somewhat loose and over-extended presentation of the major theoretical sources of the System, principally the work of Harry Stack Sullivan. Leary refers to his approach as "dynamic behaviorism" and at one point defines, "The interpersonal factors of personality are those conscious or unconscious processes which people use to deal with others and to assess others and themselves in relation to others. The aim of interpersonal machinery of personality is to ward off anxiety and preserve self-esteem."

Part II, entitled, "The Interpersonal Dimension of Personality: Variables, Levels and Diagnostic Categories," presents 5 "levels of personality," each level defined in terms of operations which produce the pertinent data. To this reviewer this section contains the most significant theoretical-functional contribution.

Part III presents "Indices of Variability," by which conflict is measured through analysis of interlevel discrepancies. The variability indices are not described in detail nor is their "validation and clinical applicability" included in the book.

Part IV and V offer concrete illustrations of the application of the System: first, its use in clinical diagnosis; and second, its application to hospitalized psychotics, psychosomatic types, group dynamics in industrial groups and interpersonal dynamics in group psychotherapy.

The use of operationally defined "levels of personality," measured using the same frame of reference, seems to be the most exciting aspect of the system. The three most important levels are:

I The level of Public Communication, which consists of the overt behavior of the individual as rated by others. (In such situations where "Others" are not available Leary has applied the MMPI to obtain Level I descriptions.)

II The level of Conscious Communication, which consists of the subject's reported percepts of himself and his interpersonal world.

III The level of Private Communication, which abstracts from the projective, indirect fantasy productions of a subject an interpersonal self-image and a symbolic world of "others."

Eight generic ways of interaction have been isolated for use as the overall variable system. They are: (1) Managerial-Autocratic, (2) Com-

petitive-Narcissistic, (3) Aggressive-Sadistic, (4) Rebellious-Distrustful, (5) Self-Effacing-Masochistic, (6) Docile-Dependent, (7) Cooperative-Overconventional, and (8) Responsible-Hypernormal. These are organized in a circular continuum, in which all the interpersonal variables are systematically related to each other, and of which the major axes are love-hostility and dominance-submission. Any sample or group of samples of interpersonal behavior can be classified through the use of this circular matrix.

A simplified illustration of the system's use and potentiality may be offered here. A person may be described as extremely dominant by those who know him and may see himself in the same way, whereas his fantasy heroes are largely passive. The multi-level numerical description of this individual would be 1-1-5, and this can be presented graphically as well on the basic circle; the ease of classifying people by the use of this numerical diagnostic technique is striking. Qualitatively, the conflict between the person's conscious and unconscious views of himself is extreme. Additionally, he is consciously aware of how he is seen by others.

The presentation of the system is functional. The data for Levels I and II are obtained by the use of the Interpersonal Adjective Checklist and for Level III from tests of fantasy such as the TAT. This data is easily obtained; test administration, scoring and rating can be done by non-professional, well trained technicians. The book, with the addition of a manual entitled, "Multilevel Measurement of Interpersonal Behavior," contain all necessary instructions for the use of the system and much data is offered on varied groups that have been studied at the Kaiser Foundation.

Interpersonal Diagnosis of Personality offers a rich, promising contribution to the area of the description of people. One is impressed with the simplicity and freshness of its approach. But, unfortunately, such praise must be qualified. The system, though brilliant on its surface, often has too weak a foundation. Some parts are supported by substantial research while others are based on very little. The offering in book form of the Interpersonal Diagnostic System seems too ambitious and too early. However, the system cannot fail to be of use to scientists concerned with problems of description and measurement of personality.

ARTHUR L. KOBLER

The Pinel Foundation,
Seattle, Washington

Manifest Structure Analysis. By FRANK M. DUMAS. Pp. ix + 193. Missoula, Montana: Montana State University Press, 1955. $6.00.

The author has set forth ambitiously conceived scaling objectives but his approach is at once hasty, unclear, and sorely lacking in empirical support. The list of topics is extensive, but the treatment has that once-over-lightly touch. What is most discouraging, perhaps, is that the sweeping claims made are certain to attract attention and interest of research workers in fields and disciplines for which the methods and assumptions of MSA are inadequate. Less preoccupation with the search for a scaling panacea and more concern with presenting strong evidence would make the author's position more tenable and his contribution more useful.

EUGENE L. GAIER

Department of Psychology,
Louisiana State University,
Baton Rouge 3, Louisiana

BOOK NOTICES

THE PERSON BEHIND THE DISEASE. By Julius Bauer. vii + 136 pp. Grune and Stratton, New York, 1956. $3.50. The objective of this book is to elaborate on the holistic concept of the person in health and disease, based on the one hand on the practical appreciation of psychosomatic unity and, on the other hand, on the uniqueness of the individual, with its genetic basis.

VERTEBRATES OF THE UNITED STATES. By W. Frank Blair, Albert P. Blair, Pierce Brodkorb, Fred R. Cagle, and George A. Moore. ix + 819 pp. McGraw-Hill, New York, 1957. $12.00. The principal aim of this usable manual is "to facilitate the identification of all known U. S. vertebrates through the assembling of taxanomic keys, check lists, descriptions and ranges." There is an introduction (30 pp.) and a glossary.

REPORT OF THE MEDICAL RESEARCH COUNCIL FOR THE YEAR 1955-1956. 270 pp. British Information Services, New York, 1957. $1.50. Informative survey of the manifold activities carried under the Council's sponsorship in clinical and basic medical sciences.

SYMPOSIUM ON NUTRITION AND BEHAVIOR. Edited by Josef Brožek. 124 pp. The National Vitamin Foundation, Inc., New York, 1957. $2.50. An interdisciplinary survey consisting of sixteen papers, plus introductory statements and an epilogue, divided into four sections: Impact of diet on behavior, Hunger and appetite, Food appraisal and acceptance by man, and Satiety and weight control.

WILLIAM HARVEY. HIS LIFE AND TIMES; HIS DISCOVERIES; HIS METHODS. By Louis Chauvois. (Tr. from French). 271 pp. Philosophical Library, New York, 1957. $7.50. "Compared with experiment, all the rest is metaphysics and dialectic—smoke and inanity." This illustrates well the author's lively style and is a testimony of his high regard for Harvey's scientific method.

GENETIC MECHANISMS: STRUCTURE AND FUNCTION. Cold Spring Harbor Symposia on Quantitative Biology, Vol. 21. xviii + 392 pp. Biological Laboratory, Cold Spring Harbor, New York, 1956. $8.00. The primary objective of the symposium was bridging of the gap separating genetics and experimental embryology. The problem of genetic mechanisms was considered at the clinical, genic, chromosomal, cellular and developmental level.

INTRODUCTION TO STATISTICAL ANALYSIS. By Wilfrid J. Dixon and Frank J. Massey, Jr. xiii + 488 pp. McGraw-Hill, New York, 1957. $6.00. Second revised edition of a substantial textbook designed for a basic course in statistics presented as a general theory and practice of testing hypotheses through the evaluation of numerical observations.

MEDICAL RADIATION BIOLOGY. By Friedrich Ellinger. xxxiv + 945 pp. Charles C. Thomas, Springfield, Illinois, 1957. $20.00. The field, considered as the younger sister of pharmacology, is presented in four sections devoted

to the fundamental considerations of the biological effects of radiant energy (104 pp.), ionizing radiations (606 pp.), ultraviolet radiation (65 pp.) and visible light and infrared radiation (23 pp.). 4600 references.

GROWTH AND DEVELOPMENT OF DENTAL AND SKELETAL TISSUE—CLINICAL AND BIOLOGICAL ASPECTS. Edited by Samuel J. Fomon. 80 pp. Ross Laboratories, Columbus, Ohio, 1956. No price. This report of the 17th Ross Pediatric Research Conference considers genetic, nutritional and endocrine factors in the "hard tissues."

SURVEY OF BIOLOGICAL PROGRESS. Vol. III. Edited by Bentley Glass. 332 pp. Academic Press, New York, 1957. $7.50. The selected vistas of the biological panorama include, among other topics, embryological concepts in the 20th century, animal genetics, chemoreception in insects, and mechanism of hormonal action.

PERSONAL CHARACTER AND CULTURAL MILIEU. Edited by Douglas G. Haring. xi + 834 pp. Syracuse University Press, Syracuse, New York, 1956. $7.50. Third, revised edition of papers by anthropologists on culturally fostered patterns of personal character. There is an introductory chapter by the editor and 5 contributions on how an anthropologist works in the field.

THE CONCEPT OF DEVELOPMENT. Edited by Dale B. Harris. x + 287 pp. University of Minnesota Press, Minneapolis, 1957. $4.75. The topic is examined by 17 authors representing a wide array of disciplines from philosophy of science through biology, psychology, and sociology to the applications in pediatrics, psychopathology, social work and education.

ALCOHOLISM, BASIC ASPECTS AND TREATMENT. Edited by Harold E. Himwich. viii + 212 pp. American Association for the Advancement of Science, Washington, D. C., 1957. $5.75. Proceedings of a multi-disciplinary symposium concerned both with the basic aspects and treatment.

TRANQUILIZING DRUGS. Edited by Harold E. Himwich. viii + 197 pp. American Association for the Advancement of Science, Washington, D. C., 1957. $5.00. These are boom days for "psychopharmacology," the study of the mode of action of drugs and the effectiveness of central stimulants, hallucinogens and—not the least of them—the tranquilizers. The current volume is concerned with the electrophysiological and metabolic analysis of their action and therapeutic uses.

HORMONES, BRAIN FUNCTION, AND BEHAVIOR. Edited by Hudson Hoagland. viii + 257 pp. Academic Press, New York, 1957. $7.00. The proceedings of a conference on neuroendocrinology, held in May, 1956, reflect the growing interest in the biochemical determinants of conduct. The 12 papers deal, from this point of view, with steroid and sex hormones, serotonin and the thyroid hormones.

A DICTIONARY OF SCIENTIFIC TERMS. Edited by J. H. Kenneth. xvi + 532 pp. D. Van Nostrand, Princeton, New Jersey, 1957. $12.50. A well established member of the Van Nostrand family of scientific dictionaries and one-volume encyclopedias. Gives pronunciation, derivation and definition of some 14,000 terms used in the biological sciences.

HORMONAL REGULATION OF ENERGY METABOLISM. Edited by Laurance W. Kinsell. xiii + 242 pp. Charles C. Thomas, Springfield, Illinois, 1957. There are 8 papers by outstanding workers in the field, including a communication on pituitary growth hormone, and extended discussions.

THE PHYSICAL GROWTH OF CHILDREN: AN APPRAISAL OF STUDIES 1950-1955. By Wilton Marion Krogman. iii + 91 pp. Child Development Publications of the Society for Research in Child Development, Purdue University, Lafayette, Indiana, 1956. No price indicated. An indispensable *vade-mecum* presenting 1) a digest of data, 2) a critique of trends and goals and 3) a fairly omnivorous bibliography.

PSYCHOLOGY, PSYCHIATRY AND THE PUBLIC INTEREST. Edited by Maurice H. Krout. xv + 217 pp. University of Minnesota Press, Minneapolis, 1956. $4.00. Assembly of papers, largely prepared especially for this volume, and of statements of policy dealing with the role of clinical psychology and its relation to psychiatry.

THE CONTROL OF THE CIRCULATION OF THE BLOOD: SUPPLEMENTAL VOLUME. By various authors. Arranged by R. J. S. McDowall. vii + 257 pp. Wm. Dawson, London, 1956. $9.00. The supplement to a reprint of McDowall's 1938 volume consists of 12 articles, by different authors, reflecting the major advances made in the last 17 years (incl. cerebral circulation, muscular exercise, and lack of oxygen.)

THE NATURE AND TRANSMISSION OF THE GENETIC AND CULTURAL CHARACTERISTICS OF HUMAN POPULATIONS. 143 pp. Milbank Memorial Fund, New York, 1957. $1.00. The papers presented at the 1956 Annual Conference of the Fund fall into three groups dealing with 1) Biological and cultural factors in human heredity, 2) Evaluation of population characteristics (personality and measured intelligence, psychiatric symptoms, fertility), and 3) genetic bases of behavior and mental disorders.

EXPERIMENTAL PSYCHOLOGY AND OTHER ESSAYS. By I. P. Pavlov. 653 pp. Philosophical Library, New York, 1957. $7.50. A biography by Kh. S. Koshtoyants and Pavlov's brief autobiography are followed by papers covering all the major aspects of his work. It is good to have them available in English, but it should be noted that only a small fraction deals with "experimental psychology." And who are the mysterious translators and editors?

INDIVIDUAL DIFFERENCES IN NIGHT-VISION EFFICIENCY. By M. H. Pirenne, F. H. C. Marriott and E. F. O'Doherty. 83 pp. British Information Services, New York, 1957. $1.44. The principal aim of the study was to assess sensory acuity and perceptual efficiency by means of specialized visual tests administered at low illuminations to dark adapted subjects.

FORSCHER UND WISSENSCHAFTLER IM HEUTIGEN EUROPA: ERFORSCHER DES LEBENS. (Research Workers and Scientists in Today's Europe: Students of Life). Edited by Hans Schwerte and Wilhelm Spengler. 339 pp. Gerhard Stalling, Oldenburg, 1955. DM 16.80. The fourth volume of the important biographical, interpretative series "Gestalter unserer Zeit" (Makers of

Our Times) is devoted to medical scientists, biologists and anthropologists (P. M. Boule—fossil man, S. K. Mollison—human evolution, E. Fisher—human biology, E. von Eickstedt—comparative human biology, R. Biasuti—anthropogeography).

ORGANIZATION OF THE CEREBRAL CORTEX. By D. A. Sholl. xvi + 125 pp. John Wiley, New York, 1956. $4.25. A unified view of recent work carried out by anatomists, clinicians, physiologists and psychologists. The author favors a theory of cortical organization employing models based on the concept of probability and discussed in statistical terms.

BIOCHEMICAL DISORDERS IN HUMAN DISEASE. Edited by R. H. S. Thompson and E. J. King. xiv + 843 pp. Academic Press, New York, 1957. $12.60. For many disorders pathological description and analysis is passing from the stage of histology to that of biochemistry. In this collaborative work (31 contributors) we find assembled and interpreted the known facts in this field.

DICCIONARIO DE PSICOLOGIA. Edited by Howard C. Warren. Translated & Revised by E. Imaz, A. Alatorre and L. Alaminos. xvi + 383 pp. Fondo de Cultura Economica, Mexico, 1956. $3.50. A translation of a dictionary first published in English, with the addition of biographical data that are not always reliable or up to date.

JOSEF BROŽEK

University of Minnesota,
Minneapolis, Minn.

INDEX TO VOLUME 29

Acheson, R. M., and C. W. Dupertuis, Relationship Between Physique and Rate of Skeletal Maturation in Boys, 167-93
Aging, 128-9
Anthropometry, 123-6
Anxiety and stress—in a life situation, 295-6

Baar, J., 126-7
Beds—effects of sleeping in, 274-88
Blood—group substances, 367-70
Body-build—and personality, 289-91
Body composition—roentgenogrammetric determination of, 337-53
Body-function—and personality, 289-91
Body volume—and weight reduction, 305-13
Boyd, W. C., 366-7
Brooks, C. McC., 274-88
Brožek, J., Book Notices, 136-8, 220-2, 301-3, 382-5; Book Reviews, 123-35, 214-9, 289-300, 366-81

Carns, M. L., and R. Glassow, Body Volume Accompanying Weight Reduction, 305-13
Cerebral hemorrhage—Japan, 139-66
Children—and plasma fibrinogen, 354-65; growth curves, 83-122; growth of South African babies, 12-39; infant growth, 194-213; physique and skeletal maturation in boys, 167-93; soft tissue changes in, 62-82
Circulatory adjustment, 217-9

Deming, J., Application of the Gompertz Curve to the Adolescent Cycle of Growth, 83-122
Demography—1955 yearbook, 126-7; 131, 296-7, 298-9
Dupertuis, C. W., 167-93

Ego structure, 132-3
Eye—relationship to hand, 314-28

Falkner, F., 214-5
Fat—roentgenogrammetric determination of, 337-53

Gaier, E. L., 381
Garn, S. M., Research in Human Growth, 1-11; Roentgenogrammetric Determinations of Body Composition, 337-53, 293-4
Gellhorn, E., 132-3
Genetic theory—differing views, 293-4
Genetotrophic concept, 215-6

Glassow, R., 305-13
Goldstein, M. S., 128-9
Gompertz curve—application to adolescent growth, 83-122
Grande, F., 215-6
Greville, T. N. E., 131
Growth—and Gompertz curve, 83-122; in first year of life, 194-213; in South African babies, 12-39; longitudinal study of, 214-5; research in, 1-11; skeletal, 167-93

Hammond, W. H., Constancy of Physical Types as Determined by Factorial Analysis, 40-61; Status of Physical Types, 223-41
Hand—relation to eye, 314-28
Harris, D. B., 129-30
Heredity—chemical basis of, 366-7
Hoffman, B. F., 274-88
Hormones—and aging process, 128-9
Human behavior—unifying theory of, 375-8
Human development—direction of, 129-30
Human fertility, 370-2
Human types—and personality, 289-91; classification and comparison, 223-41; constancy of, 40-61; origin, 329-36; physiological regulation in, 329-36
Hunt, Jr., E. E., 291-2
Hypertension—and circulatory adjustment, 217-9; Japan, 139-66

Immunology and serology, 367-70
Individual development, 214-5
Itō, H., 139-66

Knee—radiographic atlas of, 291-2
Kobler, A. L., 378-80
Koenig, E. H., 274-88
Kornfeld, W., Typical and Atypical Changes in Soft Tissue Distribution During Childhood, 62-82

Lacey, J. I., 295-6
Left-handedness, 314-28

Mair, F., 296-7
Manifest Structure Analysis, 381
Merrell, D. J., Dominance of Eye and Hand, 314-28
Montagu, M. F. A., 133-5
Mourant, A. E., 367-70

Obesity—and weight reduction, 305-13

Personality—diagnosis of, 378-80
Physical types—and personality, 289-91; constancy of, 40-61; origin of, 329-36; physiological regulation in, 329-36; present status of, 223-41

Plasma fibrinogen—in children, 354-65
Pomerenke, W. T., 370-2
Population study—296-7
Psychobiology, 217-9
Psychophysiology, 217-9

Right-handedness, 314-28

Salber, E. J., Growth in the First Year of Life, 194-213; Growth of South African Babies, 12-39
Sasaki, N., 139-66
Schull, W. J., 242-73
Sex—determination from skeleton, 242-73
Shaw, D. M., 374-5
Sirken, M. G., 372-4
Skeleton—167-93, maturation and relation to physique; determination of sex from, 242-73
Sleep—physiological effects of surfaces used, 274-88
Smoking—patterns, 374-5
Spirit—analysis of, 133-5
Statistics—life tables from limited data, 372-4; non-parametric, 299-300
Suckling, E. E., E. H. Koenig, B. F. Hoffman and C. McC. Brooks, Sleeping on Hard or Soft Beds, 274-88

Takahashi, E., N. Sasaki, J. Takeda and H. Itō, Geographic Distribution of Cerebral Hemorrhage and Hypertension in Japan, 139-66
Takeda, J., 139-66
Tanner, J. M., 123-6
Thieme, F. P., and W. J. Schull, Sex Determination from the Skeleton, 242-73
Tissue—changes in children, 62-82
Trevorrow, V. E., Longitudinal Study of Plasma Fibrinogen in Children, 354-65

Vandenberg, S. G., 299-300, 375-8

Weight reduction, 305-13
Westoff, C. F., 298-9
Wilber, C. G., Origin of Human Types, 329-36

DO NOT CIRCULATE

HUMAN BIOLOGY

a record of research

JAN 29

DECEMBER, 1957

Vol. 29 No. 4

PUBLISHED QUARTERLY BY
WAYNE STATE UNIVERSITY PRESS, DETROIT 2, MICHIGAN,
U.S.A.

HUMAN BIOLOGY

a record of research

FOUNDED BY RAYMOND PEARL

Editor
GABRIEL W. LASKER

Acting Editor
F. GAYNOR EVANS

in association with

BENTLEY GLASS
WILLIAM W. HOWELLS
JAMES N. SPUHLER
WILLIAM L. STRAUS, JR.

Review Editor
JOSEF BROŽEK

HUMAN BIOLOGY is published quarterly by Wayne State University Press. The advance subscription price is $5.00 a year, $9.25 for two years, or $13.50 for three years. Foreign postage is 35 cents per year extra; Canadian postage is 15 cents per year extra. Back issues are $2.00 per copy. Volumes 1 through 26 may be purchased from Kraus Periodicals, Inc., 16 East 46th Street, New York 16, New York.

Subscribers should notify the publishers of change in address at least two weeks before publication of the issue with which the change is to take effect. No claim for non-receipt of an issue will be entertained unless made immediately upon receipt of the next succeeding issue.

Manuscripts and communications regarding editorial matters should be addressed to Editor, Human Biology, Department of Anatomy, Wayne State University College of Medicine, 1401 Rivard St., Detroit 7, Michigan. Books for review should be sent to Dr. Josef Brožek, Laboratory of Physiological Hygiene, Stadium Gate 27, University of Minnesota, Minneapolis 14, Minn.

WAYNE STATE UNIVERSITY PRESS, *Publishers*
DETROIT 2, MICHIGAN, U. S. A.

Second-class mail privileges authorized at Detroit, Michigan.

Copyright 1957 by Wayne State University Press

INFORMATION FOR CONTRIBUTORS

HUMAN BIOLOGY, a record of research, is a quarterly journal devoted to the subject its name implies. It publishes original articles dealing with human genetics, development, growth, reproduction and aging, functional anatomy, bio-anthropology, human ecology, population dynamics, etc.

The original manuscripts, typed double-spaced on one side of 8½ x 11 inch paper in complete and finished form precisely as they are to appear, should be sent—packed flat—to the editor, Dr. Gabriel Lasker, Wayne State University College of Medicine, 1401 Rivard Street, Detroit 7, Michigan. It is desirable that a second copy be included in order to expedite prompt consideration, and that an additional carbon copy and copies of all illustrations should be retained by the author.

Where possible, illustrations should be made for reproduction as line engravings, hence drawn in India ink as boldly as possible. Lettering must remain legible after figures are reduced to fit on 4½ x 6⅝ inch pages (letters 1½ to 2 mm high after reduction are adequate). Figures should be numbered consecutively with Arabic numerals. Tables should be numbered independently from 1 up, and both figures and tables should have captions. When the amount of tabular and illustrative material is judged to be excessive or unusually expensive, authors may be requested to pay the excess cost. Galley proofs will be sent to the author and must be returned promptly; when the author makes substantial departures from copy, the cost will be charged to him. Three copies of an abstract (not to exceed 225 words) should be submitted when the proof is returned. One will be sent to the editor of *Biological Abstracts*.

References in the text to the literature should be made by using the author's name followed by the year of publication: "Studies of Garn and Saalberg ('53) . . ." At the end of the article, under the heading "LITERATURE CITED," full references with titles and inclusive page references should appear (double spaced) in alphabetical order of the authors' names: "GARN, S. M. AND J. H. SAALBERG 1953 Sex and age differences in the composition of the adult leg. Human Biol., *25:* 144-153."

Authors will receive 25 free reprints. Orders for additional reprints should be placed at the time proof is returned. It will not be possible to accept orders for reprints after the proof has been returned to the press.

Human Biology

a record of research

VOLUME 29 DECEMBER, 1957 NUMBER 4

CONTENTS

CHANGES IN BODY VOLUME ACCOMPANYING WEIGHT REDUCTION IN COLLEGE WOMEN. *Marie L. Carns and Ruth B. Glassow* 305

DOMINANCE OF EYE AND HAND. *David J. Merrell* .. 314

PHYSIOLOGICAL REGULATIONS AND THE ORIGIN OF HUMAN TYPES. *Charles G. Wilber* 329

ROENTGENOGRAMMETRIC DETERMINATIONS OF BODY COMPOSITION. *Stanley Marion Garn* 337

LONGITUDINAL STUDY OF PLASMA FIBRINOGEN IN CHILDREN. *Virginia E. Trevorrow* 354

BOOK REVIEWS 366

BOOK NOTICES 382

WAYNE STATE UNIVERSITY PRESS, *Publishers*
DETROIT 2, MICHIGAN, U. S. A.

6784